

# AUDIO ENGINEERING

FEBRUARY  
1949

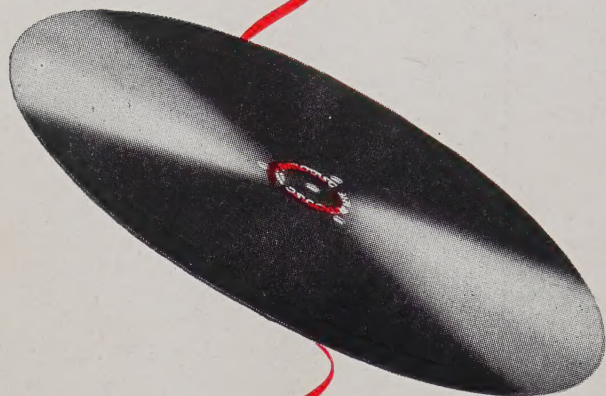
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THE JOURNAL FOR SOUND ENGINEERS

Testing—1, 2, 3

Testing—1, 2, 3

Testing—1, 2, 3



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# AUDIO ENGINEERING



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CONTENTS

FEBRUARY, 1949

Vol. 33, No. 2

Letters .....	4
Editor's Report.....	6
High-Power Triode Amplifier— <i>Walter T. Selsted and Ross H. Snyder</i> .....	9
A Flexible Dual Control System— <i>Howard T. Sterling</i> .....	11
A New Corner Speaker Design, Part II— <i>C. G. McProud</i> .....	13
An Improved Lacquer Disc Recording Head— <i>H. E. Roys</i> .....	21
Full-Range Loudness Control— <i>John Winslow</i> .....	24
Use of the Transmission Measuring Set— <i>George W. Curran</i> .....	26
Record Revue— <i>Edward Tatnall Canby</i> .....	30
New Products.....	32
1949 I.R.E. National Convention Technical Program.....	43
Advertising Index.....	52

## COVER

Light pattern photomicrograph of micro-groove audio sweep record.  
This picture was made by George A. Argabrite, chief engineer of the Clarkstan Corp.,  
using a point source light and a special lens.

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## Audio Philosophy

Sir:

Your magazine's letters department is an excellent source of information on how our creative thinking is going. But one gets confused by the apparent divergence of opinion on basic philosophy. Is there an actual difference or is it just a problem of semantics?

Broadly considered, "High Fidelity" seems one accepted universal. However, it seems to mean different things to several writers. One correspondent in your October issue implies high fidelity as being synonymous with variable gadgets. Does the fidelity rating go higher directly as the relative number of controls?

We can start establishing a common ground by assuming "High Fidelity" as a desirable end. Next, is it absolute or relative? I hold it must be absolute.

One can't argue scientifically or always agree with a Relativist because he sets up his own dynamic ends. His definitions and conclusions can quite reasonably be called Art. He works towards "improvement" of the sound.

An Absolutist might be defined as one who is striving to create a system which neither adds or subtracts from the sound as heard at the original source. He is a Relativist inasmuch as his evaluation is relative to the original Absolute.

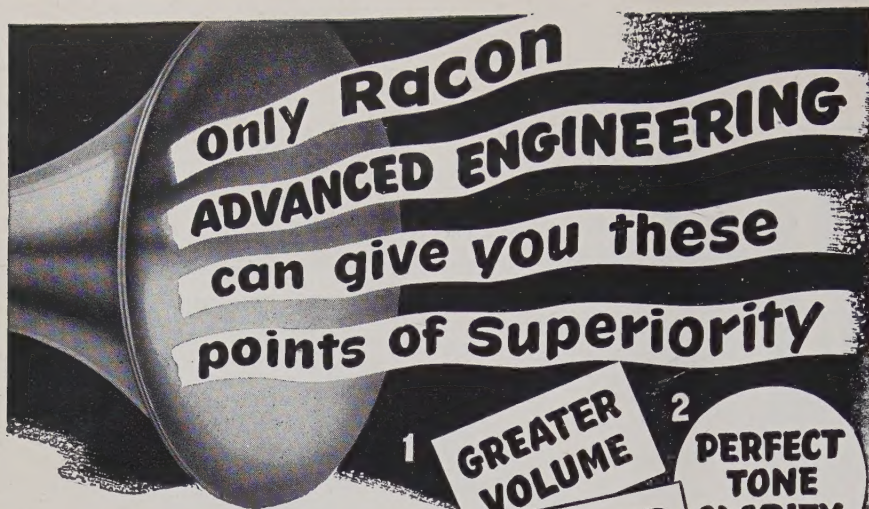
Let's not complicate the discussion by wondering if the end is a genuine scientific, or a commercially saleable instrument. This is a particular for the Economics minded to use as a digression.

Art or relativism in sound being such an intangible, I cannot begin to discuss means to this end. But considerations in striving towards an absolute can approach some universals. Shall we assume the recreation of the original sound as being Truth? Is it a valid assumption that a scientist requires knowledge rather than opinion or faith? Is this Truth desirable? If we say yes on all counts, we're in agreement and can proceed.

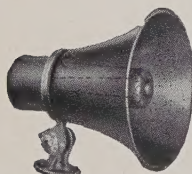
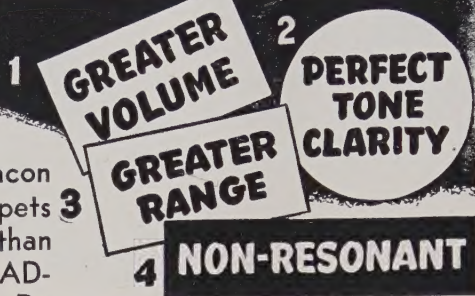
Our hero builds an Amplifier. This is the quintessence of amplifiers. His objective measurements tell him that it's flat from d.c. to the middle of what used to be the amateur 160-meter band. There are no spurious noises generated by transients. Harmonic and intermodulation distortion are negligible. He warps and twists the electrical response of the phone pickup until it's the complement of the recording frequency characteristic. The radio tuner has an ideal bandpass as measured by wobblers and scopes. The Masterpiece is created. As an afterthought, he discovers that a final electro-acoustic link is needed. So our hero selects, from a glamorous catalog, an adequate transducer for the system.

Our hero's imagination is captured by the description of a Hyper Quadra-diaphragm reproducer as described over a purse-jolting list price. "Wattaell" he says, "the Master-

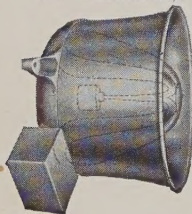
[Continued on page 35]



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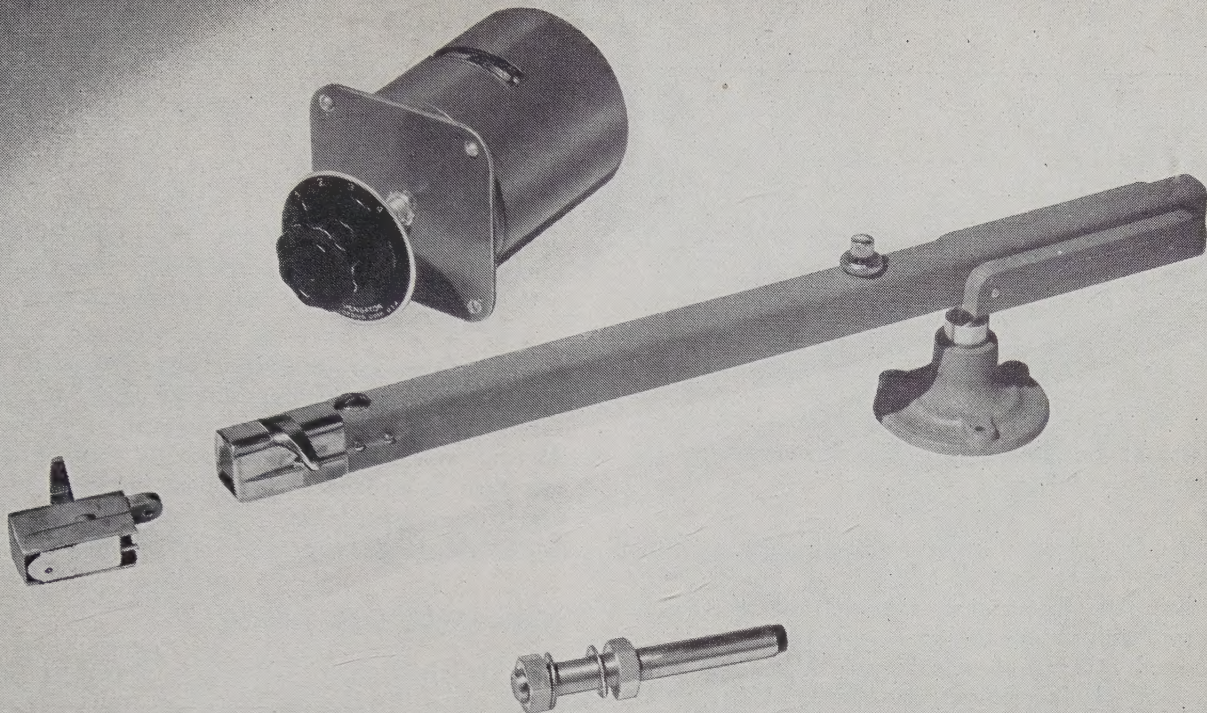
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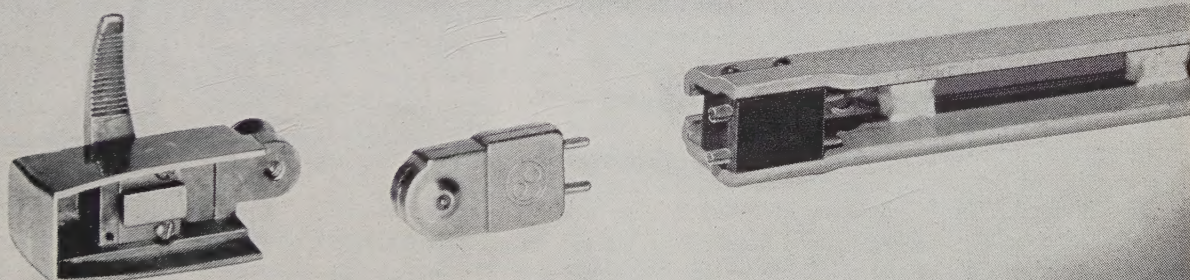


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# EDITOR'S REPORT

## DISCORD OVER DISCS

**W**HILE we don't generally poke our nose into trade wars, so much misinformation has been spread in the controversy over  $33\frac{1}{3}$  and 45 rpm fine groove recordings that we feel a few comments regarding some of the elementary engineering aspects of the case may be of interest.

In the first place, there is nothing particularly new about the present crop of long-playing records, other than their size. Sixteen-inch transcriptions, recorded at  $33\frac{1}{3}$  rpm with similar fine grooves, have been used for studio and other professional applications for many years. Long-playing records, operating at  $33\frac{1}{3}$  rpm but using coarser grooves, were manufactured and sold to the public in 10 and 12-inch sizes as far back as 1930. Because only heavy magnetic pickups were then available, needle pressure was excessive and, despite the broader groove used, there was trouble due to rapid wear. Now that we have better record material, lightweight pickups and improved manufacturing technique, it is possible to use a much finer groove without danger from this source. But a very hard point is needed.

But it is important that the speed with which the recording stylus travels should be great enough to assure a good recording. If not, high frequencies may be lost in processing or destroyed in playing if the pickup point becomes blunted. The linear speed of travel in a groove depends, of course, on the circumference of the groove as well as the revolutions per minute of the turntable. Thus the linear speed of a pickup traveling at  $33\frac{1}{3}$  rpm in a record groove 8 inches in diameter is just as fast as it would be in a 6-inch diameter groove at 45 rpm. From  $9\frac{1}{2}$  to  $11\frac{1}{2}$  inches diameter (maximum for 12-inch records) the linear groove speed of the  $33\frac{1}{3}$  rpm record is greater than that of the 45 rpm record at maximum groove speed.

If the inner groove diameter of the  $33\frac{1}{3}$  rpm records were larger than that of the 45 rpm type, there would be little point to this detailed discussion. Fact is, however, the  $33\frac{1}{3}$  LP records have a smaller minimum groove diameter than the 45 rpm type. As a result, for groove diameters of 6 inches and less, the linear speed of the  $33\frac{1}{3}$  rpm records falls below that of the 45 rpm type at its innermost groove. Therefore the manufac-

turers of the  $33\frac{1}{3}$  rpm records face processing problems not shared by those who make 45 rpm records.

Playing time for 7-inch records is 5 minutes. To offset the longer playing time ( $22\frac{1}{2}$  minutes per side) of the  $33\frac{1}{3}$  rpm LP records, manufacturers of the 7-inch 45 rpm type offer a changer with a changing cycle of less than 2 seconds. Commercial changers to handle both types of records have been announced but details are unavailable at this time.

## AUDIO ENGINEERING COURSE

Stevens Institute of Technology, Hoboken, N. J., offers a course in audio engineering to senior students with certain prerequisites. L. S. Goodfriend, research engineer, is the instructor.

## MORE AUDIO FALLACIES

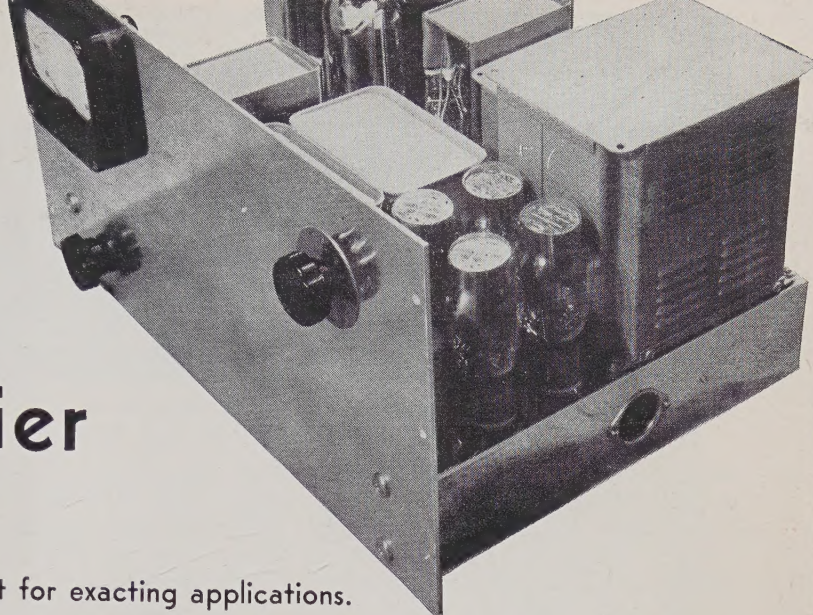
Once upon a time all original recording was done on wax; now practically everyone uses lacquer. But in daily newspapers, we still hear about jazz bands and others getting their performances embalmed in wax. In the same places wire recording is frequently talked about, but tape—never! Recently an illustration showing a tape recorder was referred to as a wire recorder in the caption.

But we make errors too. Referring to H. H. Scott's excellent noise suppressor, Canby wrote, "You can hear the noise go." The linotype operator changed this to read, "You can hear the noise *so*." We missed it. And in our discussion last month, we stated that the FCC standards specified that every AM transmitter provide a flat response (within 2 db) out to 10 kc. Actually, present standards include everything from the mike to the antenna, and, on this basis, requirements are that the frequency characteristic be flat within plus or minus 2 db from 100 to 5,000 cycles, using 1,000 cycles as the reference point. Most surprised to learn this was our broadcasting technical adviser, chief audio engineer for one of the largest networks, who has used the 10,000-cycle specs for years. As he points out, all present-day equipment for AM broadcasting easily meets the requirements he supplied last month.

—J.H.P.

WALTER T. SELSTED\*  
and  
ROSS H. SNYDER\*\*

# High-Power Triode Amplifier



The authors describe a high-quality audio unit for exacting applications.

**A**N AUDIO AMPLIFIER of high gain, high power, high stability, wide frequency range, low distortion and low noise content was required at the outset of a series of measurements of human hearing, loudspeaker performance, and recording fidelity. Because this unit was to be a link common to all the measurements, its characteristics had to exceed substantially the best expectations of the electro-mechanical equipment involved.

Calculation indicated that with loudspeakers of average efficiency peak powers of as much as 25 watts might be needed to attain the desired sound levels. A frequency range of 30 to 20,000 cycles within ½ decibel would

exceed the requirements of measurement, but good voltage regulation of the output would have to accompany the response. Because the amplifier would be used at low as well as high output levels, internal noise would have to be kept below audibility compared to the zero vu level. It was anticipated that the measurements for which this equipment was constructed would take some weeks or months to complete, and since the data accumulated would be correlated, extraordinary stability would be a requirement in the amplifier. Finally, every reasonable precaution had to be taken against introducing distortion products in the amplifier, of whatever obscure origin, which would offend the most sensitive listener.

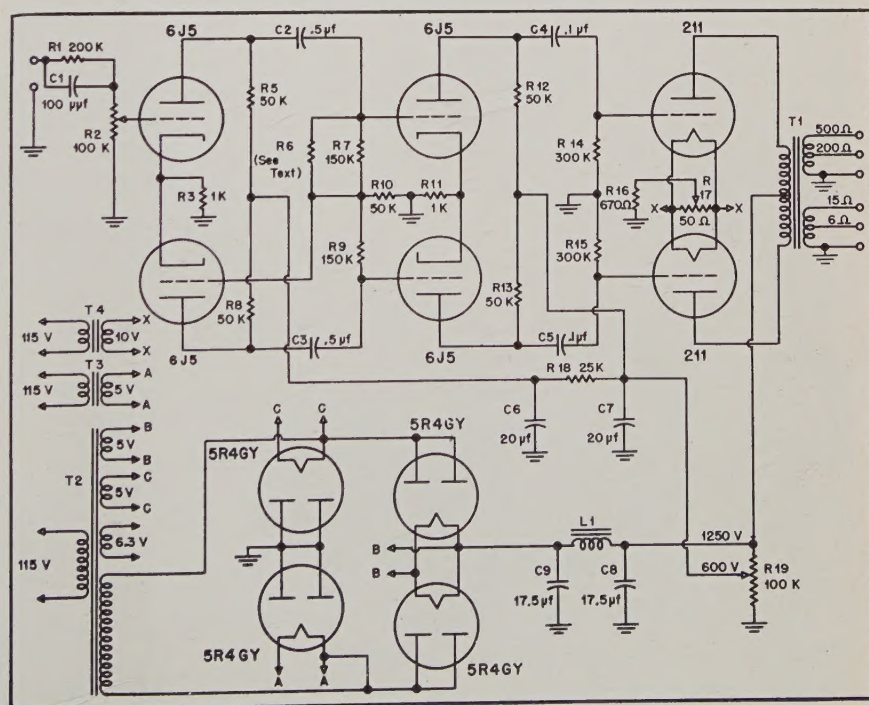
With these requirements in view, the long smooth curves of the larger triode power tubes looked attractive. An opportunity to evaluate the results to be had from the high costs usually associated with triode designs thus presented itself also.

## Low Cost Components

Funds for the experiments were no more plentiful than usual, so the possibility of using low-cost war-surplus tubes was explored. The rather formidable 211 has for a long while been in copious supply at prices comparable to those of receiver types. Power supply requirements, always severe in triode designs, at first made it appear an uneconomic choice, but a reasonable solution was found. The wide demand among radio amateurs for power equip-

Fig. 1. Schematic of audio amplifier.

- R1—200,000 ohms, ½ watt, carbon.
- R2—100,000-ohm wire-wound potentiometer.
- R3, R11—1000 ohms, 10 watts, wire-wound.
- R5, R8, R12, R13—50,000 ohms, 10 watts, wire-wound.
- R6—(see text).
- R7, R9—150,000 ohms, ½ watt, carbon.
- R10—50,000 ohms, ½ watt, carbon.
- R14, R15—300,000 ohms, ½ watt, carbon.
- R16—1000 ohms, 50 watts, slider adjusted to 670 ohms.
- R17—50-ohm 4-watt potentiometer, wire-wound.
- R18—25,000 ohms, 10 watts, wire-wound.
- R19—100,000 ohms, 200 watts, with slider, wire-wound.
- C1—100  $\mu$ f, mica.
- C2, C3—0.5  $\mu$ f, 600 volts, oil-filled.
- C4, C5—0.1  $\mu$ f, 600 volts, oil-filled.
- C6, C7—20.0  $\mu$ f, 600 volts, oil-filled.
- C8, C9—17.5  $\mu$ f, 1500 volts, oil-filled.
- T1 U.T.C. PVM-3
- T2 U.T.C. S-43
- T3 U.T.C. S-54
- T4 U.T.C. S-62
- L1 U.T.C. S-31



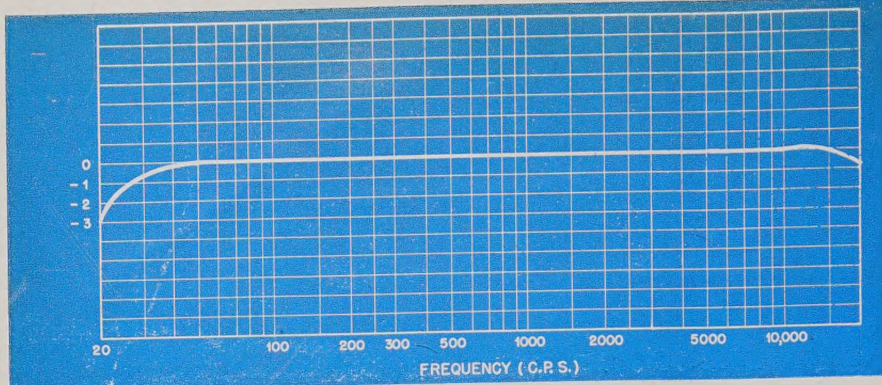


Fig. 2. Frequency response curve of audio amplifier at 30 watts output. Note that it is flat within less than one db from 30 to 20,000 cycles.

ment in this range has resulted in quantity production of the required transformers at tolerable cost. High-voltage condensers were available through war surplus. And a bridge rectifier was feasible with the low-priced 5R4GY rectifier tube, with its comfortable 250 ma current rating, and 2100 inverse peak voltage capability. The problem appeared surmountable if costly interstage transformers could be avoided.

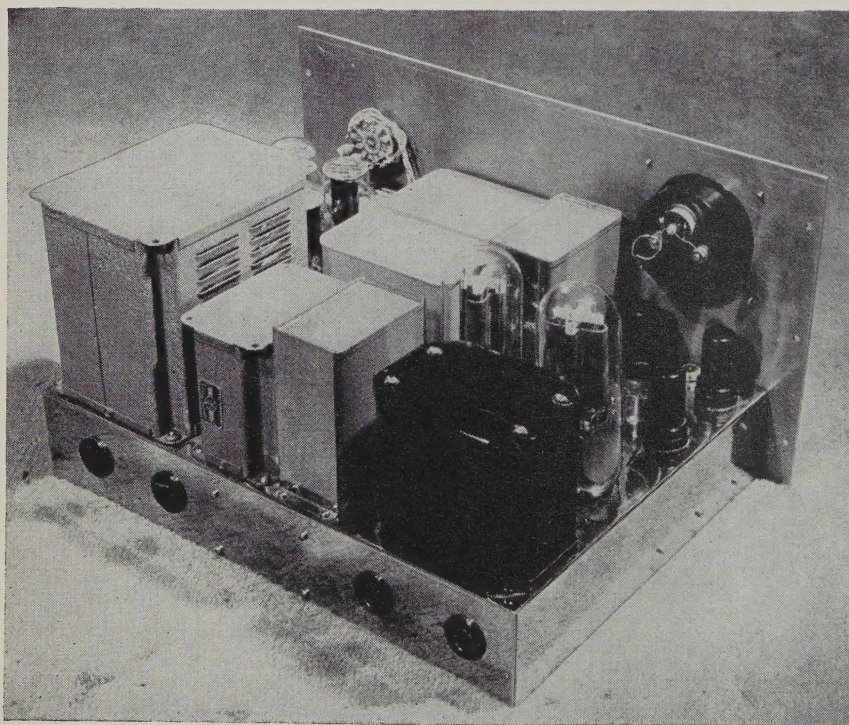
So the 211 was tentatively selected, and in the interest of reducing drive requirements, insuring stability of operation, and eliminating the necessity of a fixed-bias supply, pure class A connection was proposed.

The availability of very high plate-supply voltages suggested the possible use of ordinary receiver triodes in conventional resistance-coupled circuits. The calculations revealed that this would be the most critical section of the amplifier, but with 600 volts at the

high-potential end of the 6J5 plate resistors these tubes, operating at nearly full rated dissipation in push-pull, would drive the 211s just beyond the requirements.

The medium-mu driver triodes dictated the use of another stage of voltage gain, which could conveniently use the same tube type. Phase inversion was removed to the input stage so that degeneration in the drivers' cathode resistor would tend to remove any unbalance in a.f. grid-to-ground voltage remaining after inversion. The 6 decibels of gain added by making the input a push-pull stage was also desirable. The need for high stability with high gain demanded a tube inverter of unusual characteristics. The cathode-loaded inverter was rejected, despite its stability, because of the possibility of cathode-filament hum, a considerable hazard where relatively high gain follows inversion. Gain requirements ruled against the cathode inverter too.

As shown, the amplifier is built on a standard rack chassis.



The ordinary voltage-divider type was eliminated by its necessity for constant readjustment with tube aging. The stability and gain of the conventional floating-paraphase inverter were attractive, but its never-quite-perfect balance was a disadvantage. In the end a modification of the latter type proved satisfactory: the load on the input tube was varied by shunting  $R7$  with  $R6$ , of varying values above a megohm, until a virtually perfect balance of a.f. to the driver grids was obtained. The floating-paraphase action maintained the balance over long periods of use.

The final refinement in the circuit was the addition of a short time constant filter in the input, calculated to counteract the high-frequency losses within the amplifier due to distributed shunt capacitances. High-frequency losses due to Miller effect, often experienced in high-impedance triode grid

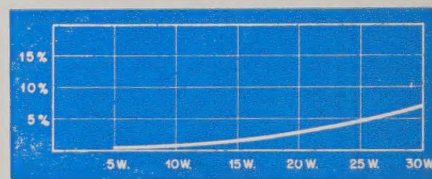


Fig. 3. Intermodulation distortion vs. power output.

circuits, were held to a minimum by the 100,000 ohm value assigned the input potentiometer. This value likewise reduced the chances of frequency discrimination from RC effects, prominent in many higher-impedance input designs.

Again in the interest of low noise level and high stability, wire-wound resistors were used in all d.c.-carrying circuits, and oil-filled capacitors were used throughout. If a suitable quality of oil condenser is used for coupling, d.c. leakages will remain even after long use at values lower than those found in new paper condensers, keeping the grids essentially at ground potential, with attendant long-time circuit stability. In the presence of heavy a.c. fields the shielding afforded by the can construction is probably a considerable advantage too.

The photographs show how the entire unit was mounted on a single standard rack chassis. The controls illustrated on the front panel are for gain and metering level.

It should be noted that potentially lethal voltages exist on the underside of the chassis. No high-voltage contacts are brought to the top. The equipment is mounted so that no access can be had to the underside without first disconnecting the power.

[Continued on page 36]

# Flexible Dual Control System

HOWARD T. STERLING\*

Describing a continuously variable R-C system providing boost and cut for both treble and bass, without the use of inductances or feedback.

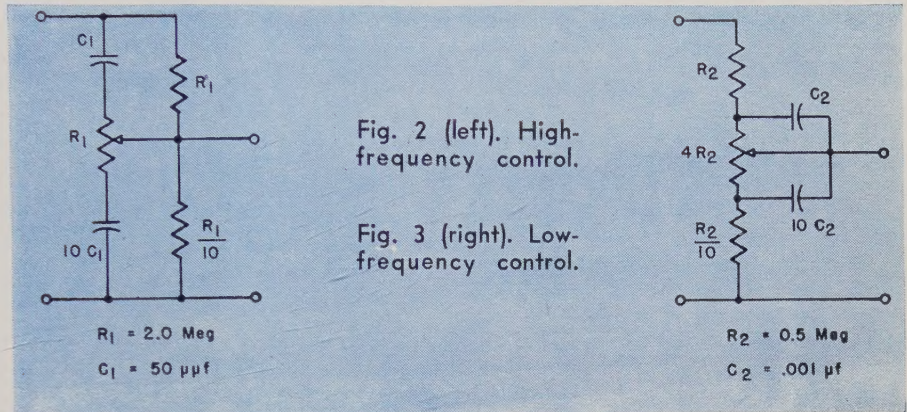
IN RECENT YEARS the term "tone control" has become anathema in the ears of self-respecting engineers. There has been good reason for this—usage in the field has generally been such that wherever a tone control has been used it has resulted in deterioration of quality.

The conventional treble control, as used in most inexpensive systems, acts to depress the whole high-frequency range, usually above 1000 cps or so. The bass control is too often a simple variation of this which provides a rising bass characteristic by reducing the relative amplitude of the highs, and usually affects the over-all volume level. Some manufacturers, desiring somewhat more effective control, often resort to a system involving selective inverse feedback. Unfortunately, in order to obtain significant results by this method it is usually necessary to include more than one R-C section in the feedback loop, with attendant regeneration and transient distortion. It is small wonder that with methods such as these the tone control has fallen into ill repute.

## Step-Type Controls

A more reasonable approach to the problem has been made by some of the manufacturers of so-called "professional" equipment. There the usual solution lies in the use of "step-type" treble and bass controls. It is possible by this means to get much more satisfactory performance, and typical curves (Fig. 1) indicate a good choice of treble cutoff and bass boost. The selling point on this method is usually that "... This is the type of control used in commercial and broadcast equipment." Unfortunately, most users of this system find the step-type of adjustment exceedingly annoying, and would much prefer that tone control be continuously variable.

It can be further demonstrated that it is desirable to be able to cut the lows as well as to boost them,

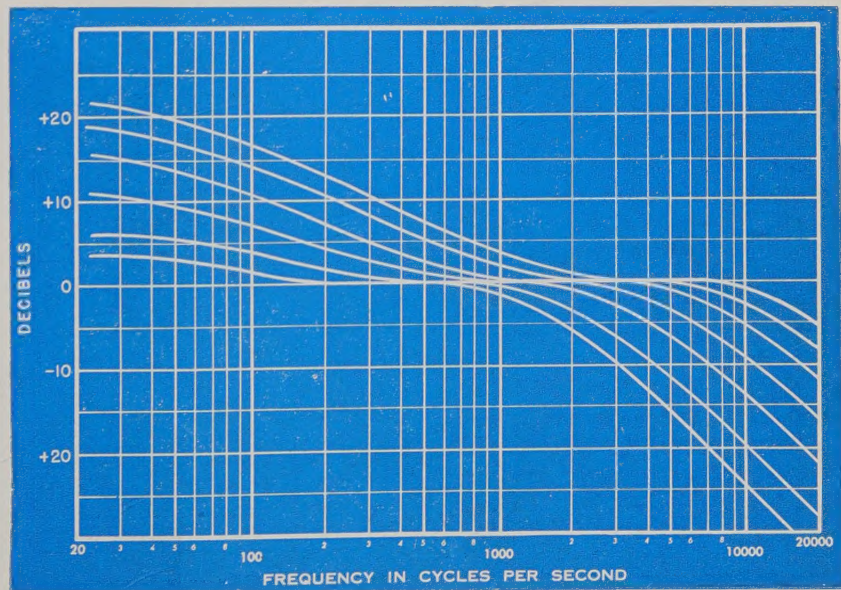


and to boost the highs as well as to cut them. Often, particularly on AM, program material comes through with a muddy quality, and reproduction may be rendered much more pleasing and intelligible if the low-frequency response can be reduced. Often too, the high frequency content of the program will leave something to be desired, and the use of judicious treble boost will restore much of the quality that is missing. There are many engineers who believe that a balance between highs and lows should be maintained, and

that if bass is boosted, treble should be boosted accordingly.

Among the popular approaches to the problem of a truly flexible dual-tone-control system are a reversion to the selective feedback method using an iron-core choke, and one using resonant circuits (again with iron-core inductances). While these systems provide a wide range of boost and cut, their proponents make no comment on matters of distortion and transient response, and a careful study of their response characteristics gives rise to some question as

Fig. 1. Typical characteristics of step-type bass and treble controls from "professional" amplifier.



\*c/o Electronic Workshop, Inc., 351 Bleecker St., New York City.

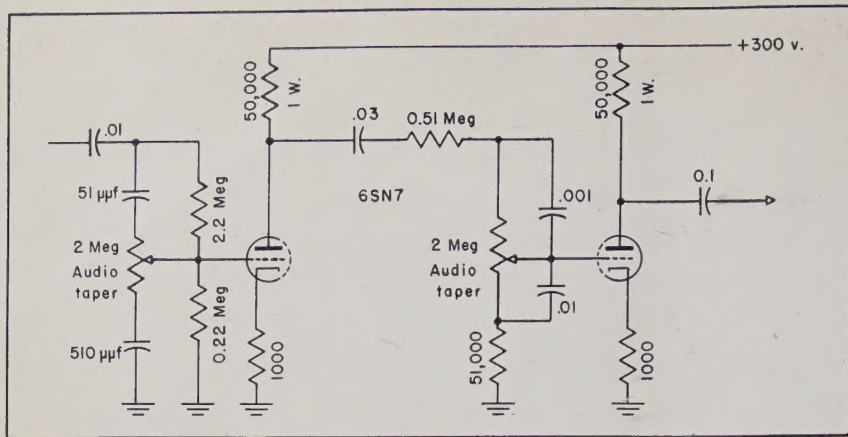


Fig. 4. Dual tone control system.

to whether they are most judiciously chosen.

There appears to be good reason to consider 800 cps as the effective center of the audio spectrum. Considerable work has been done to indicate that the combination of high and low frequency cutoffs in a system is optimum when their product equals 640,000; it is true that the frequency limits of the ear, which are in the neighborhood of 40 to 16,000 cycles, yield approximately this product; and the square root of 640,000 is 800. Some research by the Navy during the war indicated 800 cps as least irritating for long periods of listening to code, and a simple experiment with an audio oscillator and speaker will show it to be that pitch which sounds neither high nor low to the ear, in much the same way that water that is "lukewarm," is neither hot nor cold to the touch.

#### Median Point

It seems reasonable, therefore, to take 800 cps as our median point in the design of a tone-control system, and to state that boost or cut at the high or low end should have negligible effect on the gain at 800 cps.

There is a further point to this. The ear is most sensitive in the 2000-3000 cps range, and it is in this range that it can be made most uncomfortable by blaring highs and by harmonic distortion of lower-frequency sounds. Indeed, some of the speaker manufacturers build a rise into their speakers in this region in an attempt to gain an effect of brilliance, but to the critical ear the sound is merely raucous.

By taking the 800-cps midpoint as fixed, then, and commencing the treble boost above that point, the boost will not be seriously troublesome in this critical region, but will be considerable at higher frequencies where it is really needed.

The low-frequency boost is less

critical, but it still should not affect the level at 800 cps; all too often "bass boost" has its maximum effect at 200 or 300 cps. Actually the boost should really begin to be significant around 100 cps, and continue below that. Only then is the full effect achieved on bass strings and drums, where it is most needed.

Figure 2 shows a relatively simple high frequency tone control circuit. The configuration is not wholly new, but when components of the relative values indicated are used it has a number of unique advantages. By using an ordinary "audio taper" potentiometer (one in which the 10 per cent resistance point is reached at 50 per cent rotation), the response will be flat when the control is in mid position. In the extreme boost position the high frequency rise begins at about 800 cycles, and becomes extreme between five and ten ke, but the cut takes place an octave higher, so that it is possible to reduce the higher frequency noise and distortion if desired, without sacri-

ficing the brilliance of the middle highs.

The low-frequency counterpart of this circuit is shown in Fig. 3. This has a slightly different characteristic, inasmuch as the point of inflection varies as well as the slope. This conveniently supplements normal phonograph "turnover point" equalization, since it makes it possible to change the effective point of compensation. In the extreme boost position it provides all the bass most systems can handle, and in the intermediate cut positions it provides a wide range of low-frequency attenuation which proves to be desirable in practice.

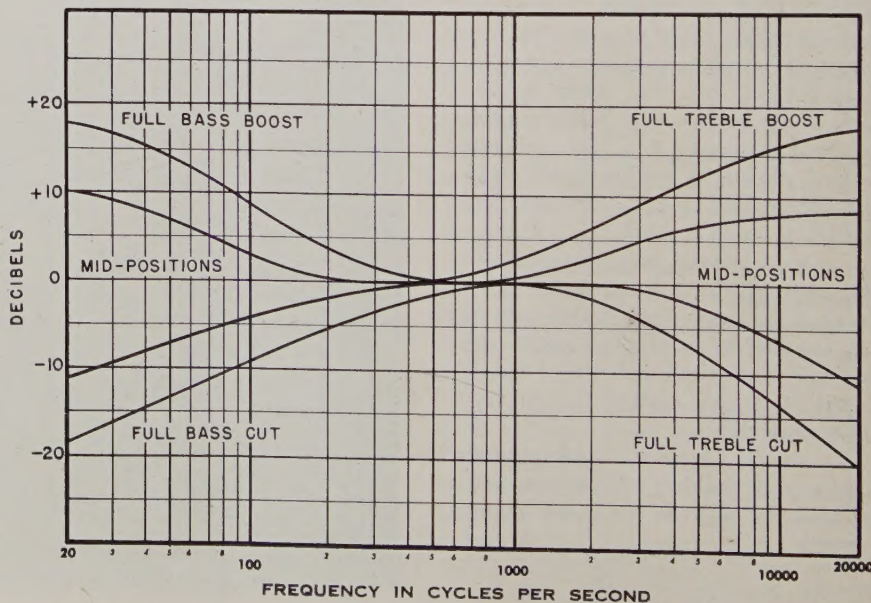
#### Losses

The disadvantage of these circuits lies in the fact that they introduce a loss of 20 db each at 800 cps. This can best be overcome by using them in conjunction with a dual triode, as shown in Fig. 4. This system has a measured response characteristic, for various settings of the controls, as shown in Fig. 5. It will be seen, of course, that the resistor from the grid to ground of the first triode may be replaced with a volume control.

It must be understood that this system should only be used to supplement proper equalization of the various program sources, and in no way obviates the need for proper compensation in the phonograph for turnover and pre-emphasis, for normal de-emphasis on FM, or for an adequately compensated volume control.

Ed. Note: The circuits of Figs. 2 and 3 must work directly into a grid to be effective in the amount shown in the curves of Fig. 5.

Fig. 5. Characteristics of dual tone control.



g. 1. The completed two-way speaker system housed in an attractive modern corner cabinet, with a 12-inch television tube in the optimum position with respect to the loudspeaker for realistic sound.

# A New Corner Speaker Design

C. G. McPROUD\*

## PART II

Final details on the construction of this revolutionary speaker housing which also accommodates television facilities.

THE AUDIO ENGINEER, enthusiast, or experimenter will probably never be completely satisfied with any part of a reproducing system. Because of this, he will design and build continuously in the never-ending search for something better in amplifiers, equalizers, or loudspeakers. It is generally agreed that while the electrical components are fairly close to perfection—or at least can be made so by careful design and construction—the electro-acoustic elements such as pickups, microphones, and speakers are still somewhat short of the ultimate goal.

At the risk of appearing complacent, the writer is presenting a design based on standard reflexed cabinet principles, yet adding a few more unique features. Reviewing Part I momentarily, this cabinet operates with the room corner as part of the acoustic enclosure; it has reflexing elements, but loads them by means of the wall and the cabinet sides; and to equalize the loading on both sides of the cone, it includes horn loading on the front of the low-frequency speaker. The corner increases efficiency slightly—about 2 db—and offers a relatively large cubic content without becoming too massive.

The design also provides plenty of space for a complete television receiver—though it was never intended to house the radio and phonograph equipment—using a 12-inch picture tube, or with slight modifications, the imminent 16-inch metal-walled tube. Part I described the lower portion

of the cabinet, comprising the low-frequency speaker and the TV tube compartment. This part covers the balance of the construction, consisting primarily of the superstructure, along with the installation instructions and performance characteristics.

### The Superstructure

All of the cabinet above the top—lettered (A) in *Fig. 5* of Part I—is called the superstructure. It is primarily an ornament, since it serves no function except to enclose the high-frequency unit and horn and the TV chassis. This section is permanently attached to the top, and when the speaker is to be moved, the top and superstructure are detached from the lower cabinet, since the complete

assembly will not go through a standard door.

The actual measurements will depend upon the high-frequency horn and unit selected and its placement so as to leave room for the TV chassis. *Figure 2* shows a view of the interior with a standard RCA 630TS blank chassis in place—since the cabinet was designed to house this particular receiver which is available in kit form from Tech-Master Products Company at a considerable saving over the completed model. Since some modifications must be made, it seemed desirable to start from the blank chassis and build the entire receiver—the true experimenter's viewpoint.

In the figure, it will be noted that

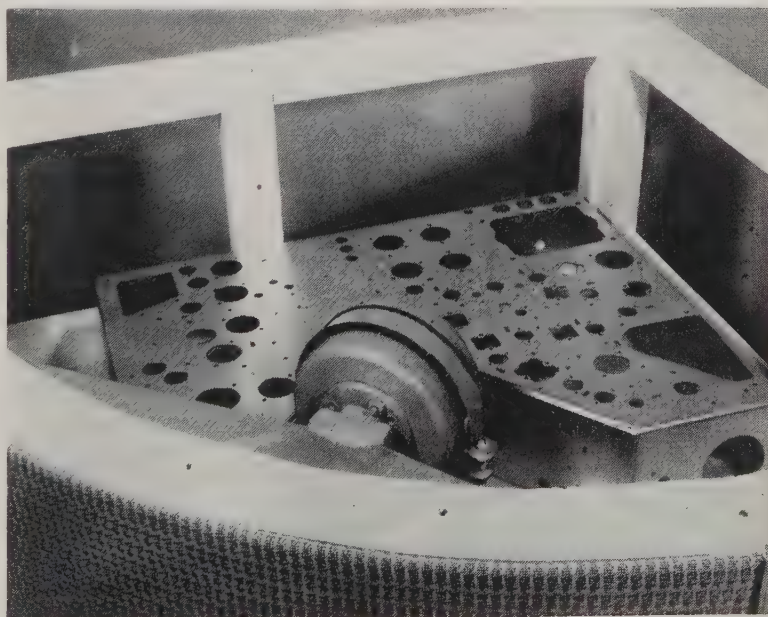


Fig. 2. Interior of the superstructure, showing the positions occupied by the television chassis and the high-frequency horn and unit.

Managing Editor, AUDIO ENGINEERING  
McProud, "A New Corner Speaker Design," AUDIO ENGINEERING, January, 1949.

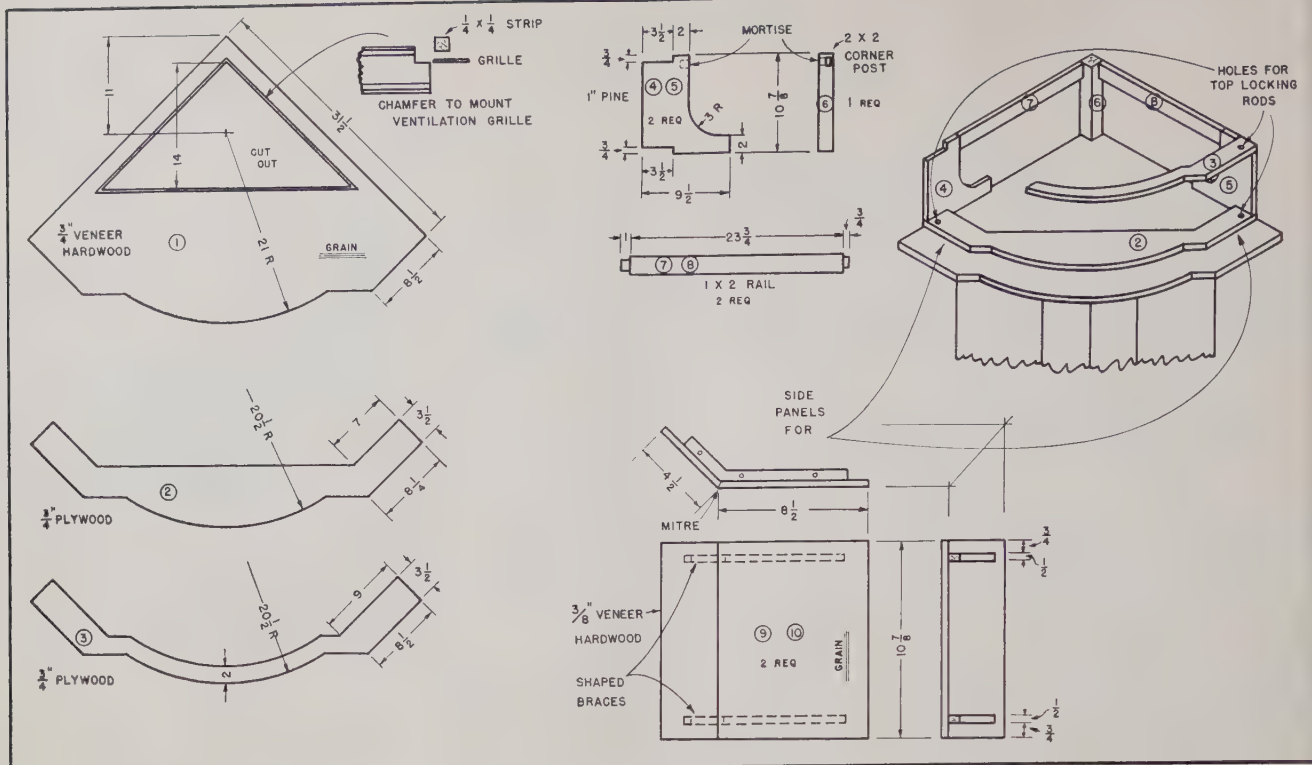


Fig. 3. Details of the various parts comprising the superstructure.

some of the controls on the rear apron are hard to reach, due to the lower strip of the frame. Therefore, the design shown in *Fig. 3* differs slightly from the photo. Except for the top panel and the two side panels, the material is pine, and is assembled with casein glue and flat-head wood screws. The side panels and the top are removable, the latter by a simple method.

Since it was not considered desirable to have screws showing on the top, the fastening consists of two 5/16-in. rods, threaded on both ends, which extend from the center deck and engage two T-nuts which are set into the top panel and fastened with flat-head wood screws. Wing nuts are threaded onto the lower ends of the rods and peened on so they serve as handles, as shown in *Fig. 4*. The cotter keys keep the rods from dropping out of the hole in the upper framework, so there is no difficulty in engaging the T-nuts when the top is put in place.

The triangular cut-out is filled with a perforated metal grille to serve as ventilation for the TV receiver, which draws nearly 300 watts, and consequently needs free circulation of air. The two side panels are assembled of 3/8-in. veneer, of the same wood as the tops and the front; they are simply screwed to the grille support. The TV controls are

brought through these panels—the channel switch, fine tuning, picture and sound-volume controls at the right—by means of shaft extensions. The brightness and hold controls vary d-c voltages, and are extended from the chassis with long leads and placed in symmetrical positions on the left side panel.

Since the two controls on the right use concentric dual knobs, the method of extending these shafts is shown in detail in *Fig. 5*. This requires long rods and conventional shaft couplings for the center shafts, and a brass tube with bushings for the outer control in order to clear the couplings, as shown.

It may be desirable to include an a-c outlet on the top so as to accommodate a lamp or clock. It is equipped with a length of wire to plug into a dual outlet on the TV tube cover, which also mounts the high-frequency speaker unit, and a plug which receives the output of the TV receiver. All connections to the top section are carried through an 8-terminal Jones plug and receptacle, the latter being mounted on the back of the tube housing.

The screen in front of the high-frequency horn consists of another piece of perforated metal, covered with a piece of plastic grille cloth. Since the color obtainable did not appear entirely suitable with the fin-

ish of the woodwork, a piece of black buckram was placed between the metal and the plastic cloth to darken the over-all effect. This effectively hides the high-frequency horn, although both the perforated metal and the horn should be painted a light color so as to avoid the appearance of a dark mass behind the cloth. Although it is claimed that the speaker is functional and not too much effort is expended to disguise its appearance, the grille in front of the high-frequency horn was added as a concession to over-all eye-appeal.

#### H-F Speaker Mounting

It is necessary to provide access to the tube compartment, so the high-frequency horn and unit are quickly demountable. Jumbo banana plugs were mounted on the front corners of the horn, and on the mounting block for the unit, and jacks were set into the framework for the front pair, and into the tube cover for the rear ones. The electrical connections for the high-frequency unit are carried on the latter two, and the entire h-f speaker may be lifted bodily from the jacks when necessary, without the need for watching phasing. The a-c outlets and a receptacle for the TV output are on the same tube cover, and all connections are carried through a short jumper cable to the male Jones plug.

Needless to say, the high-frequency speaker must be phased correctly before its final position is determined. This is best done by feeding a tone at crossover frequency to the speaker and reversing the high-frequency leads until the greatest output is obtained from the entire system, preferably measuring the output by a microphone and another amplifier with a volume indicator at its output. Then the high-frequency speaker is moved backward and forward until the maximum output is obtained. If the additional equipment is not available, put a tone at the crossover frequency on the system, and listen to first one speaker and then the other, moving the ear up and down in a plane parallel with and about 18 inches from the front of the cabinet. If the speakers are correctly phased, there will be a continuous tone heard from one speaker to the other. If not, there will be a null somewhere between them. At the crossover frequency (900 cps for the constants shown in Part I) it should not be possible to detect any difference between the two speakers as the head is moved up and down. Try moving the high-frequency speaker backward and forward until there is no difference between the two sound outputs, then check by listening to male voices on the complete system. Optimum results can be obtained without instruments if necessary, and the lack of them need not deter anyone from assembling a satisfactory system. It is suggested, however, that after deciding upon the correct position and phasing for the high-frequency speaker, this position be marked carefully. Then, live with the system for a week or so before making the mounting permanent. Try shifting the unit back and forth while listening to a familiar record or program. Make sure that the optimum position is determined before the job is considered complete. Using the network shown in Part I, the front of the high-frequency horn will just about coincide with the front of the cabinet when phasing is correct.

#### TV Receiver Placement

The entire superstructure was planned to house the Tech-Master kit receiver, since this model has an excellent reputation for performance. Other models could undoubtedly be fitted into the space if desirable, but this chassis has a cutout for the tube which fits around the high-frequency unit with efficient utilization of the space. With the chassis selected,

however, it is certain that performance with 12 or even 16-inch tubes will be satisfactory. If the kit is to be built for the purpose, the controls normally mounted on the rear apron might be relocated on the main chassis deck in the area normally occupied by the focus and deflection coils.

Connections to the picture-tube socket should be made through a 5-prong socket and plug, and those for

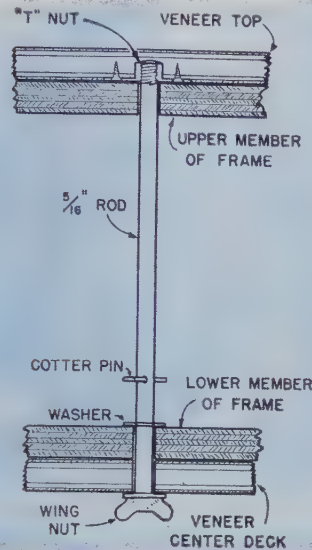


Fig. 4. Method of fastening the top to the superstructure without exposed screws to mar the appearance.

the focus and deflection coils should be made with an octal socket and plug. It is necessary to carry a ground connection to the brackets which mount the two coils so as to have a ground for the outside coating of the tube, as well as for protection during adjustments. For the high-voltage connection, it is suggested that a banana jack be installed on the Bakelite insulating strip where the lead normally leaves the high-voltage compartment. This permits the chassis to be removed for servicing without unsoldering any connections.

The picture tube is a Sylvania 12LP4, selected because it is directly interchangeable—except for size—with the 10BP4 normally used with the 630TS receiver. The requirements for deflection angle are nearly identical, and the d-c and signal voltages necessary are the same. The Sylvania tube has an essentially flat screen, and features an ion-trap type of electron gun. For best results, these two characteristics are important, and they governed the choice of the tube. The screen size with this tube is  $7\frac{1}{2} \times 10$  in.

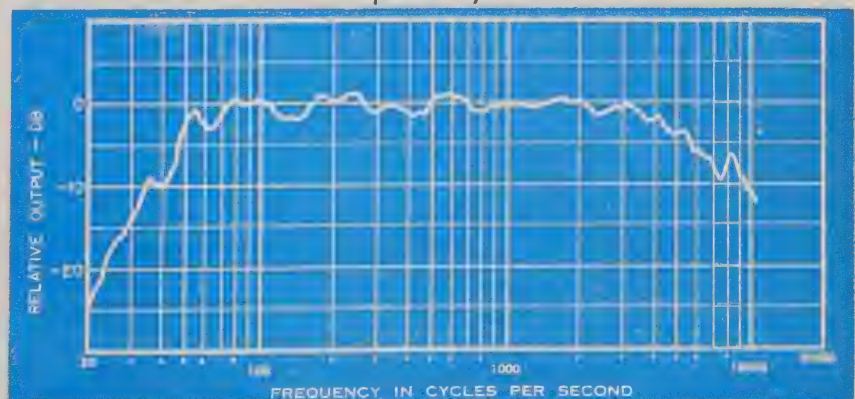
The focus coil and the deflection yoke are mounted on the hand-hole cover in the tube compartment, uscover in the tube compartment. The tube is centered in the compartment, with padding all around for protection. The leads are brought up through notches along the side of the tube compartment cover. The positioning of the tube is shown in Fig 6. A plastic mask is mounted on a  $\frac{3}{8}$ -in. oak front panel, providing both protection for the face of the tube and masking for the picture area.

#### Woodwork Finishing

In the cabinet shown, the front and tops are oak veneered, treated in the blond "rift" finish. This is a simple operation, consisting solely of painting the well-sanded oak surface with one coat of Firzite, allowing it to dry for about five minutes, and then wiping it off. The white remains in the grain of the wood, and gives an interesting finish. After the paint dries for about 24 hours, the surface should be waxed thoroughly. The speaker well, the sides, and the edges of the tops are lacquered with two coats of ensign blue Larcoloid, which gives a glossy finish from a brush coat.

This particular treatment may not appeal to everyone, but it is modern and attractive, and requires a minimum of work. Since the entire de-

Fig. 7. Measured response curves, showing performance of the two-way corner speaker system.



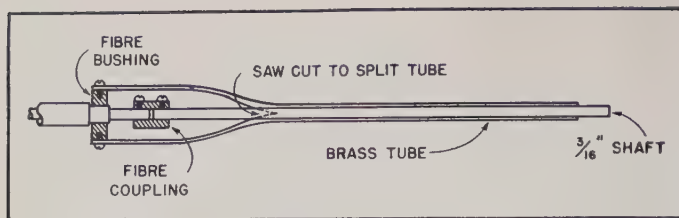


Fig. 5. Manner in which the television receiver dual controls are extended to the control panel by extension shafts.

sign is essentially modern, it is felt that the surface treatment should also be modern.

After the cabinet is completed, it should be permanently installed as outlined in Part I. Two rings are mounted at the sides of the tube compartment. To these are attached 8-in. lengths of chain, which are connected in turn to 4-in. turnbuckles. Another length of chain is attached to the other end of each turnbuckle, and looped as closely as possible over a large screw hook inserted in the floor right in the corner of the room. The turnbuckles are then tightened up, sealing the top against the wall. Originally it was planned to use a steel cable, but the difficulty of attaching the hooks and turnbuckles to the cable ruled it out after a few trials. The chain is much simpler. It may be desirable to deaden the chain with a cloth sleeve over it, or by lacing venetian blind cord through the links. The gasket used for the top is a 5/16-in. braided clothesline, tacked on the ends and glued into the groove for its entire length. The sides of the cabinet are spaced from the wall by ordinary

door stops—adjusted to the required 1½ in. by selecting the point at which they are attached to the cabinet.

#### Performance

Subjectively, this speaker system seems to be the answer, in the opinion of the writer and of several others who have heard it. It gives the feeling of a wide source of sound, as would be expected since the separation between low- and high-frequency speakers is approximately 33 inches from center to center, and the very low frequencies come from the side vents. The overall width of the speaker from wall to wall on the plane of the front is 65 inches. This wide-source effect is pleasant in the extreme and until it is experienced, the listener may doubt its advantages. A similar effect may be obtained for a trial by connecting two or three speakers to the output of an amplifier, and placing them well apart.

Figure 7 shows the measured sound output with an Electro-Voice Model 630 microphone and a sensitive a-f voltmeter, the microphone

being at a distance of six feet from the front of the cabinet. The curve is corrected for the measuring equipment as completely as possible. The tones above 200 cps were obtained from a warble-frequency record, while those below were obtained from an audio oscillator.

The signal input was held constant at the input to the 6AS7G main amplifier, which is flat from 20 to 13,000 cps, so the output represents the actual operating characteristics of the speaker with its normal driving amplifier.

The efficiency is evaluated by comparing the setting of the high-frequency attenuator with that used when the identical components were assembled with a 7-½ cu. ft. reflexed cabinet of conventional design. With the old cabinet, balance was obtained with 6 db in the h-f attenuator, while only 4 db is required with the corner speaker. This indicates that the low-frequency speaker is 2 db more efficient in this cabinet than it was with the standard box.

This is the second speaker built using the same principle of design, and the results in both cases certainly seem to justify the expectations. Performance compares favorably with medium-size theatre systems, and it has "presence"—the intangible characteristic of realism which gives the desired feeling that the performer is actually in the room.

The next step is the design data for a smaller unit, using a good 12-in. speaker with an Atlas HF-1 tweeter, and without TV facilities. This should be much simpler to construct, and if good components are used it is quite probable that results should be comparable to this first model. The smaller model of the corner speaker will be the subject of a future article.

## — NEWS —

### EMI Adopts Scott Suppressor

Electrical and Musical Industries Ltd., the leading British manufacturers of radios and records will feature the H. H. Scott dynamic noise suppressor in all new model phonograph and combinations. This results from a contract recently signed by Sir Ernest Fisk, E. M. I. Managing Director and H. H. Scott, inventor of the suppressor and President of Herman Hosmer Scott, Inc., during Mr. Scott's recent visit to London. The license agreement covers Great Britain and Australia.



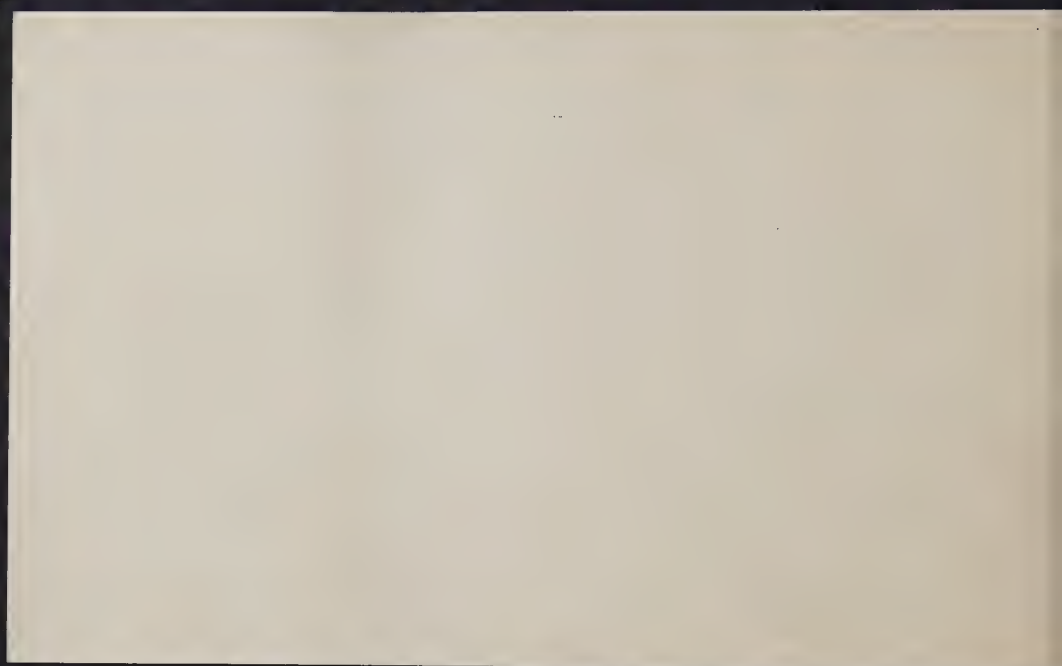
Fig. 6. Mounting of picture tube in compartment, showing relative position of various components.

## *NOTICE!*

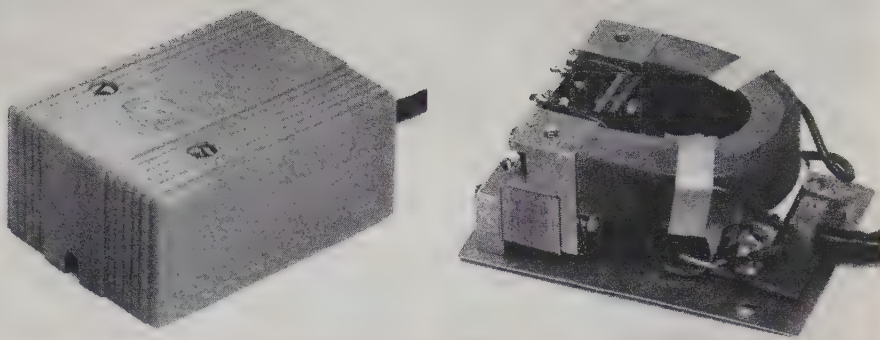
The 4-page message to you from one of our  
advertisers has been postponed because of a  
printing problem.

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Watch for the important announcement in  
our subsequent issues.



Left: MI-11850-C recording head. Right: Heater assembly mounted in place on the recording head.



*An Improved*

# Lacquer Disc Recording Head

H. E. ROYS\*

A new recording head with excellent characteristics is described.

WHERE speech or music is recorded for direct playback, slight variations in frequency response (in the order of two or three db) are not easily detected and are therefore relatively unimportant. However, for recordings such as masters which are to be processed, or to be used for re-recording, slight changes in response become objectionable and must be minimized. Flat amplifier response is usually easily obtained, but flat cutter response is more difficult since the components of an electromechanical system are not as readily controlled as those of an electrical network. Adequate corrective filters can be designed, however, leaving problems of temperature changes, stylus loading, and changes in the medium after cutting, due to cold flow or spring-back. Stylus loading has been investigated with the aid of the FM calibrator<sup>1</sup> and the magnitude of variation is not believed to be excessive for most applications. Improvements resulting from temperature control have made it desirable to incorporate this feature in the RCA MI-11850-C recording head.

## Recording Head Design

In many recorder designs<sup>2</sup> the moving system has compliant members between the mass elements which permit them to vibrate in different phase relations at the higher frequencies and so act as separate masses. As a consequence, there is an effective reduction in mass at the higher frequencies which results in an increase in sensitivity and a wider frequency range. The RCA lacquer

disk recording head MI-4887 as originated by H. J. Hasbrouck<sup>3</sup> was designed utilizing such principles and these are retained in the MI-11850-C. By properly proportioning the masses and compliances, a mechanical arrangement analogous to the electrical network of a low-pass filter is obtained (see Fig. 1). As in the case of the electrical filter, the correct terminating impedance is necessary in order to obtain a smooth transmission characteristic. The termin-

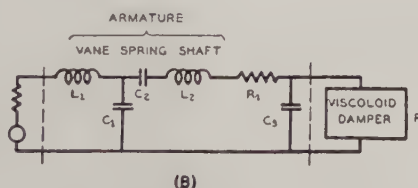
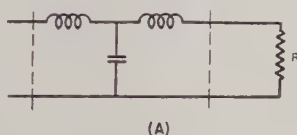


Fig. 1a. Low-pass electrical filter. Fig. 1b. Equivalent electrical network for a mechanical recorder.

ation impedance for the cutter consists of a semi-hard plastic material known as "viscoloid" which exhibits good mechanical damping properties. The magnitude of the damping that is required to flatten the resonance peaks and give a smooth response characteristic is considerable, but this is an advantage as changes in loading while cutting will then have little effect upon the recording characteristic. The ideal case would be to have the mechanical impedance of

the recording head so great that its response due to stylus loading while cutting wax or lacquer would be unaffected.

Unlike electrical resistance, true mechanical resistance is difficult to obtain. Utilization of the viscous properties of oil is a means often resorted to in obtaining mechanical damping. Oil and viscoloid or rubber-like substances which are used in pickups and cutters exhibit some change in characteristics with temperature when closely examined. The FM calibrator allows measurements of stylus motion within a few tenths of a db and has permitted a study of such variations with an ease and degree of accuracy not available heretofore.

## The Heating Problem

From the heating standpoint we have a large mass of metal which does not require heating and a small block of damping material that does, all mounted in a thin-walled plastic case. To surround the entire unit with heat-insulating material to maintain all the parts at a uniform temperature would result in a large, bulky, impractical unit. It was believed that by mounting the heater between the damping block and the thermostat, and locating the thermostat so that its temperature would be nearly that of the viscoloid, a reasonable degree of temperature control could be maintained. Preliminary tests indicated that such an arrangement would be satisfactory, and the development and design work was continued along this line.

## Operating Temperature

Ideally the temperature should be high enough so that it is never ex-

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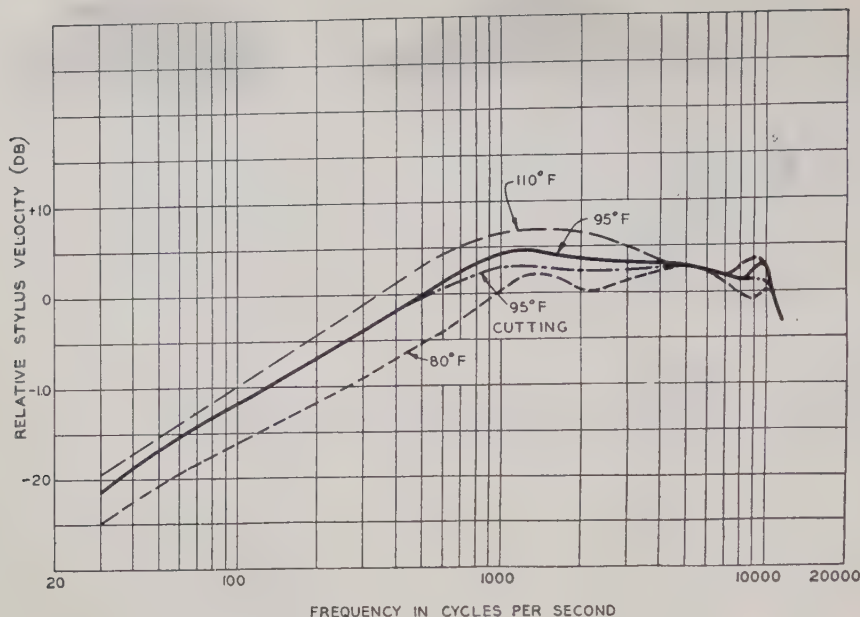
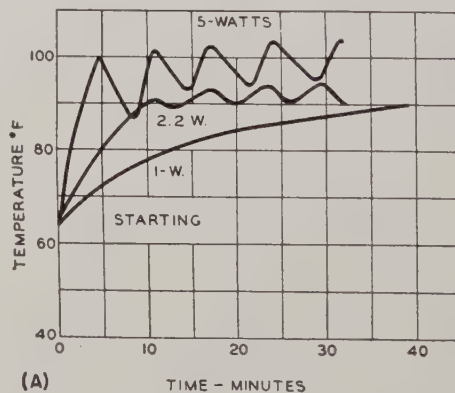


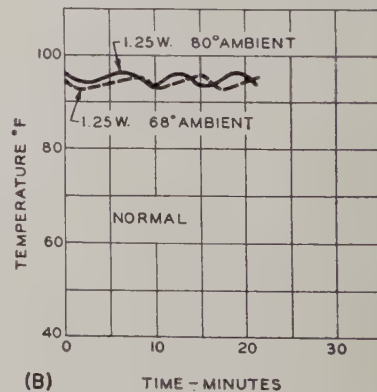
Fig. 2. Change in response with temperature.

ceeded during operation. This may be impractical, however, and a somewhat lower temperature may be found that is just as satisfactory. Tests were made at many different temperatures, and the results of these are shown in Fig. 2. The curve obtained at 80° F. could possibly be made smoother by adjusting the viscoloid damper, but the trend toward smoothness with a higher temperature such as 95° F. is clearly evident. An operating temperature of 110° F. is too high, as sufficient damping at the fundamental resonance (about 1200 cycles) is not readily obtained without a radical change in the damper block design. The dotted curve marked "cutting" was obtained while actually recording a lacquer disc and shows the decrease in level due to loading of the stylus tip. The other curves were taken with the stylus vibrating in air or unloaded, in order not to confuse loading changes with those caused by temperature. The improvement in sensitivity at the low frequencies with a higher operating temperature is well illustrated by the curves. A temperature of 95° F. was finally selected as the normal operating value.

The ideal case would be to apply a minimum of power and so have the current flowing a major portion of the heating cycle. Too great a power dissipation causes wide fluctuation in temperature as is illustrated in Fig. 3a, where tests were made using three different powers, with the thermostat set to open at 95° and close at about 93° F. Overshooting occurred and a maximum temperature of 104° was observed when five watts were being dissipated; with 2.2 watts the fluctuation was less; and with one watt the fluctuation was small, but the warm-up period was

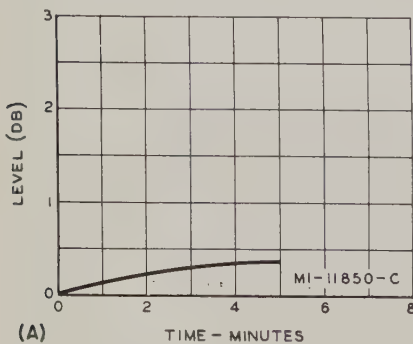


(A)

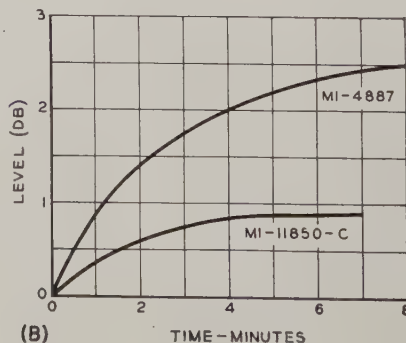


(B)

Fig. 3 (above)a. Warm-up time and temperature fluctuations at damper block for different heater dissipation. Fig. 3b. Temperature fluctuations after suitable warm-up time.



(A)



(B)

Fig. 5a. Continuous application of sine-wave signal causes some increase in recording level at 1000 cycles. Fig. 5b. Continuous application of 5000 cycle signal causes a greater change in level at 1000 cycles. Note, however, the improvement obtained with the MI-11850-C over the MI-4887, which was not temperature controlled.

found to be long. These tests were made at an ambient temperature of 65°; at an ambient temperature of 80° and a power dissipation of 1.25 watts, the fluctuation was found to be reasonable, and this power was selected for normal operation.

### Quick Heating Control

The warm-up period required by the 1.25 watts is long and to reduce it, and also provide sufficient heating for operation below an ambient temperature of 65°, an externally mounted resistor of seven ohms is used in series with the heater (14.5 ohms). This resistor is shunted by a switch which, when closed, applies 2.75 watts to the heater. From the curves of Fig. 3a, it can be seen that a warm-up period of about ten minutes with this amount of dissipation is necessary. Once the operating temperature is reached, the shorting switch should be opened so that normal power will be applied, resulting in minimum temperature fluctuation.

### Low Temperatures

The normal power of 1.25 watts is sufficient to maintain the operating temperature of 95° with an ambient temperature as low as 65° F. Below 65°, automatic operation may be obtained by connecting a thermostat across the external resistor to short it out for temperatures below 65° and so apply full power (2.75 watts) to the heater. With this increase in heater power, good temperature control is maintained as low as 45°. The hardness of the lacquer

increases greatly as the temperature is decreased, making it difficult to cut a smooth, quiet groove. It is therefore questionable whether recording blanks were also warmed.

#### Additional Benefits

Some of the additional benefits derived from operating the viscoloid at 95° F. have been mentioned. Stability and smoothness of response is one. Calibration checks over long periods of time show very little change in response, as illustrated by Fig. 4, in which measurements were made at a six-month's interval. An increase in sensitivity throughout the low-frequency end, where the peak energy of program material is the greatest, is another. Increased sensitivity requires less current and hence less flux for a given amplitude of cut, and usually results in less distortion in the magnetic circuit.

Continuous application of sine-wave signal causes some additional heating not experienced with program material containing speech and music. The increase in level found when applying a 1000-cycle signal is shown in Fig. 5a. At other frequencies, continued application of an oscillator signal produced practically no change in recording level. However, if a high-frequency signal was applied for an appreciable time and the response at 1000-cycles checked, a greater change in recording level was noted than when only the 1000-cycle signal had been used. This is believed to be due to magnetic losses, causing the armature to become hot and in turn heat the viscoloid attached at the end of the armature shaft and so change the damping characteristic. Considerable improvement in this respect has been measured with the MI-11850-C, as can be noted in Fig. 5b, where a comparison with an MI-4887 is made.

This change in recording level should not present any difficulties in program recording, for which the cutter is primarily designed. However, when calibrating or making frequency runs, long applications of high-frequency sine-wave signals should be avoided.

The increase in sensitivity also results in a shift of the crossover point (constant velocity to constant amplitude of stylus motion) to the lower frequencies. This is desirable, as less electrical compensation is then required in order to meet the NAB standard lateral recording characteristic with its theoretical crossover at 500-cycles. A typical response characteristic while cutting at an average diameter at 33-1/3 r.p.m. is shown in Fig. 6.

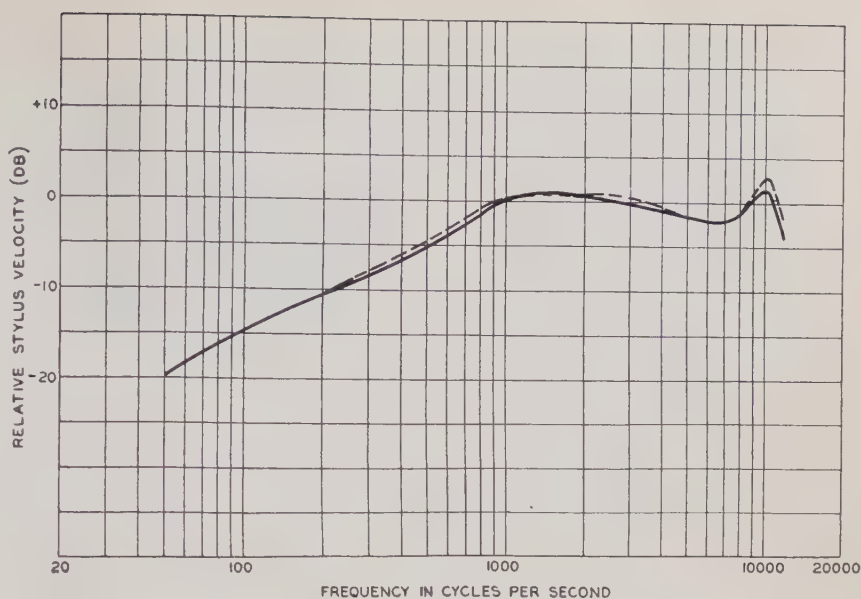


Fig. 4. Response measurements taken six months apart. Note only a slight change, an improvement resulting from controlled temperature operation.

#### Mechanical Improvements

The appearance of the MI-11850-C is different from that of its predecessor, the MI-4887, due to a re-arrangement of the mechanical parts, mainly the permanent magnet that supplies the d-c flux. This was done to minimize the mechanical bounce<sup>4</sup> often encountered during recording where the cutter oscillates vertically, cutting grooves of varying depth. By decreasing the inertia and properly locating the pivot points, this form of instability has been reduced to a minimum and anti-resonators or dash pots are no longer required. An advance ball holder with an adjusting screw which projects through the case has been designed for those who wish to use this method of groove depth control.

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4. H. E. Roys: "Force at the Stylus Tip While Cutting Lacquer Disk Recording Blanks," *Proc. I.R.E.*, Vol. 35, No. 11, (Nov. 1947), pp. 1360-63.

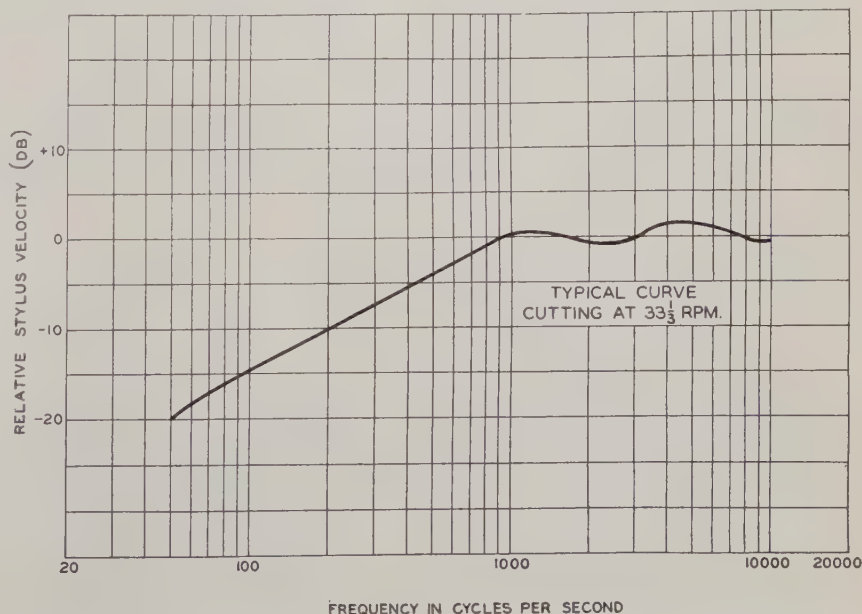
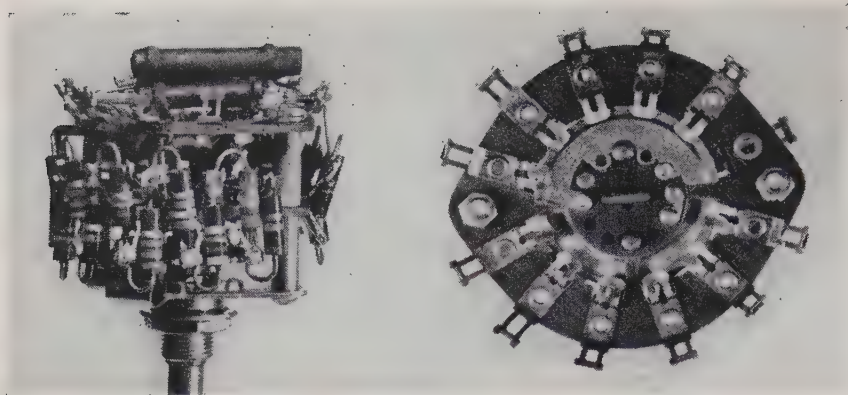


Fig. 6. Typical response characteristic while cutting at an average diameter at 33-1/3 r.p.m.



# Full-Range Loudness Control

JOHN WINSLOW

This simplified loudness control uses commercially available components and may be assembled in an hour or so.

SINCE the publication of David Bomberger's "Loudness Control for Reproducing Systems"<sup>1</sup> many readers have expressed considerable interest in this device, mainly with a desire for a control having a larger number of steps so as to be more suitable for use as the only volume control in a radio and phonograph installation. Such a unit was described in the series on "Residence Radio Systems"<sup>2</sup> but no data were given other than the schematic of the particular network employed. The photograph showed an enclosed control, using the frame of an IRC attenuator.

This control is not readily available in jobbers' stores, and the construction of a loudness control on this frame is rather a difficult procedure, so the arrangement described herein was assembled in an effort to reduce the work involved, and to use

only those components which are readily available to the experimenter. The result is shown in *Fig. 1(A)*. In addition, a means is provided to reduce the low-frequency boost, thus furnishing one form of tone control for use with the system.

Actually, however, one of the principal advantages of the fully compensated control lies in a reduction of the need for conventional "tone controls." While tapped volume con-

trols are a step in the right direction, their effect is comparatively minor, and when the volume is reduced considerably, additional low-frequency boost is required to retain the correct aural balance. It will be found in most installations that the proper use of the fully compensated loudness control will eliminate most of the need for the tone control and, as has been mentioned before, the apparent quality remains constant over a wide range of audio level.

Two precautions are necessary in using a loudness control. The most important is that all input sources *must* be adjusted to approximately the same level. This means that separate controls must be available between such sources and the selector switch, as shown in the block schematic of *Fig. 2*. The second precaution is that the loudness control be followed by a grid circuit, with no intervening controls. If these two precautions are followed, the loudness control will be a revelation to any-

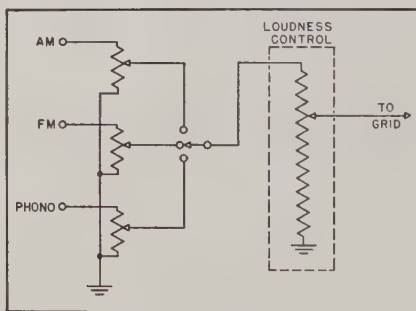
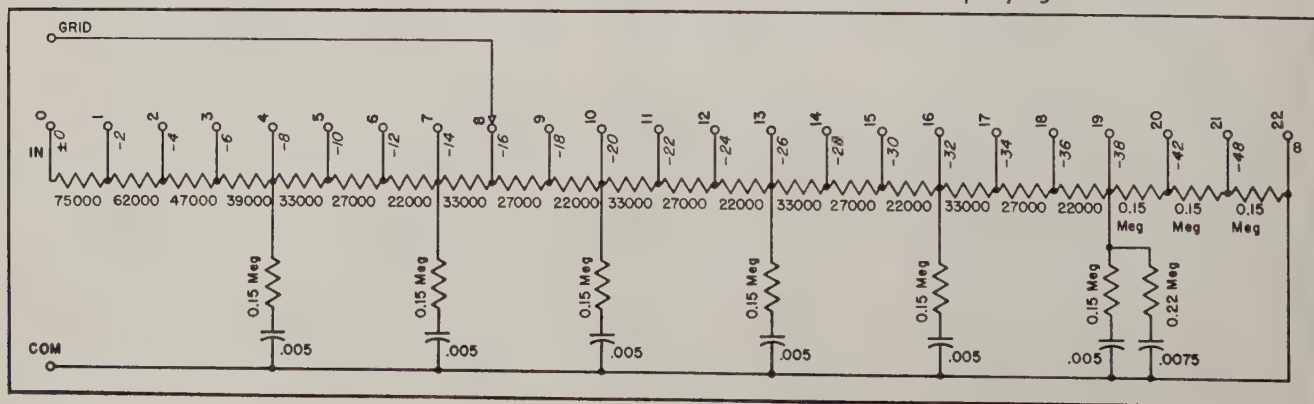


Fig. 2. Block schematic of the preferred method of connecting the loudness control into an amplifier circuit.

Fig. 3. Schematic of the loudness control described in the accompanying article.



he who installs it in a reproducing system.

## Control Design

The fundamental features of the loudness control were discussed thoroughly in the Bomberger article, and need not be repeated here. Suffice that it is desirable to vary the frequency response simultaneously with level so as to present a signal which is adjusted to match the sensitivity of the ear to various frequencies at different loudness levels, in accordance with the well-known Fletcher-Munson curves. To make such a control useful as the main gain control of a system, its total range must be of the order of 50 db, and the average change in level between steps about 2 db. This is accomplished by the control whose schematic is shown in Fig. 3. The attenuation for 1000 cps at the various steps is indicated on the schematic, while the frequency response at several of the steps is indicated by the curves of Fig. 4. These are actual measured values, using 10 per cent resistors (except for two values which are available only in the 5 per cent range). All these resistors are of random selection, but it is seen that they approximate the requirements of the desired control.

## Construction

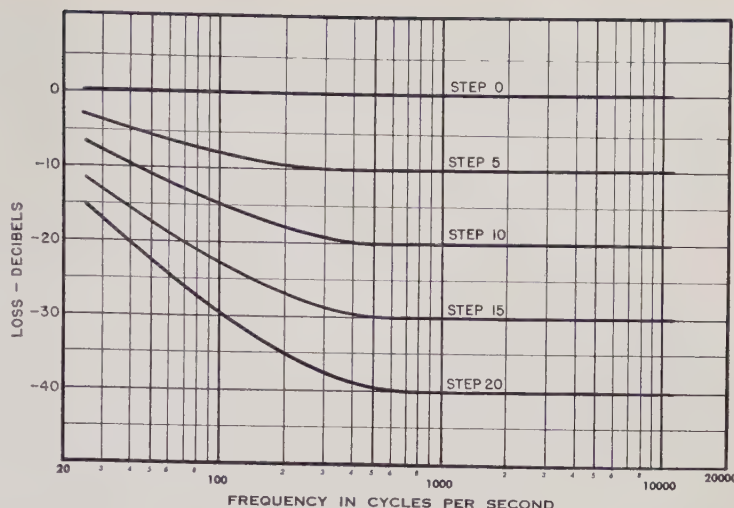
The following material is required for the loudness control:

- 1 Centralab 1443 switch (23 point)
- 1 Centralab K-121 index assembly
- 1 Centralab "B" switch deck
- 1 0.22-meg  $\frac{1}{2}$ -watt resistor
- 9 0.15-meg  $\frac{1}{2}$ -watt resistor
- 1 75,000-ohm  $\frac{1}{2}$ -watt resistor
- 1 62,000-ohm  $\frac{1}{2}$ -watt resistor
- 1 47,000-ohm  $\frac{1}{2}$ -watt resistor
- 1 39,000-ohm  $\frac{1}{2}$ -watt resistor
- 5 33,000-ohm  $\frac{1}{2}$ -watt resistor
- 5 27,000-ohm  $\frac{1}{2}$ -watt resistor
- 5 22,000-ohm  $\frac{1}{2}$ -watt resistor
- 6 .005- $\mu$ f Centralab Hi-Kaps
- 1 .0075  $\mu$ f Centralab Hi-Kap

The K-121 index assembly is listed because of the need for two long screws to mount the "B" switch deck, as well as for two  $\frac{1}{2}$ -in. spacers. However, in most instances, the user will wish to make the second switch for reducing the low-frequency compensation—a decompressor—and this assembly is used for the purpose, with only a "G" switch deck being necessary in addition to the other parts listed.

The first step in the construction of the control is to remove the rotor from the "B" switch deck. To do this, break out the thin Bakelite retaining disc on one side, and carefully work the contact arm out of the lugs so as to avoid damaging the rotor. This deck is used only to

Fig. 4.  
Response  
curves  
for  
steps  
0  
5  
10  
15  
and  
20.



mount the seven capacitors, with the resistors connecting to the potentiometer at the correct points.

Next, turn the 1443 control to maximum clockwise position and note the position of the contact arm. Calling this point "O" count around in a clockwise direction (viewed from the back) and make a scribe mark on points 4, 7, 10, 13, 16, and 19. Now, solder a 0.15-meg resistor to each of these marked points, with the leads through the eyelets holding the lugs, and allowing only about  $\frac{1}{16}$ -in. between the resistor body and the eyelet. Attach the 0.22-meg resistor to the lug of point 19 as closely as the others, but do not solder. At this point, the switch deck will be shown in Fig. 5.

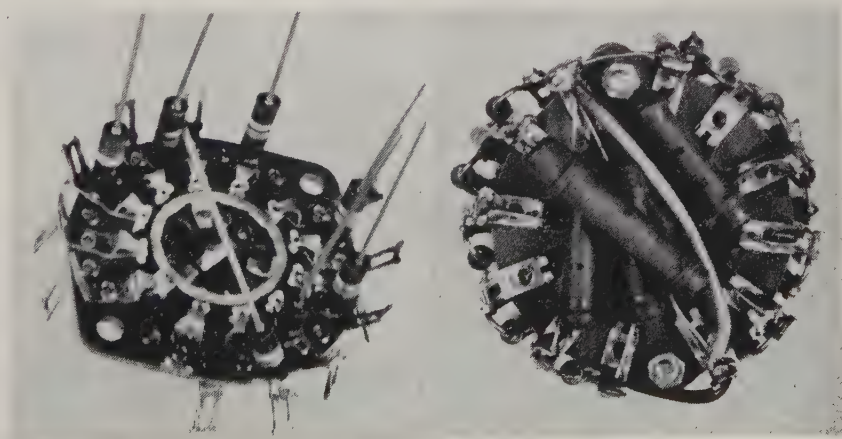
The two screws holding the switch together are now removed—one at a time—and replaced with the longer ones, with a  $\frac{1}{2}$ -in. spacer between the 1443 switch deck and the de-rotated "B" deck. The resistor leads should be fed through convenient lugs on the latter as it is put in place

so as to avoid bending the short ends of the resistor leads, as would be necessary if the connections were made later. After the new deck is mounted and the nuts firmly tightened, the remaining 22 resistors may be mounted.

In starting the first of these connections, the wiring may appear to be a bit tricky, but a little experience will make it quite simple. Bend one lead of each resistor back 180 deg. around the tip of long-nosed pliers. The two leads may then be easily inserted through the lugs—one resistor from one side, the next from the other, and so on. When all the resistors are mounted and soldered, including the soldering of the 0.22-meg. resistor on point 19, the six capacitors are mounted on the "B" deck. Three unused lugs are employed for the ground connection, as shown in Fig. 6. These grounds should be strapped to the 23rd lug on the main deck, leaving sufficient wire for making the connection to

[Continued on page 39]

Fig. 5 (left). First step in connecting the resistors to the 1443 switch deck. The 0.15-meg shunt resistors are mounted first, as shown. Fig. 6 (right). Method of mounting the compensating capacitors on the de-rotated "B" switch deck.



# Use of the Transmission Measuring Set

GEORGE W. CURRAN\*

Practical applications of this versatile apparatus.

CONSIDERABLE INFORMATION regarding the design and properties of transmission measuring sets (gain sets) has been presented in the literature during the last few years,<sup>1,2</sup> but there does not seem to have been very much published regarding details of the use of these sets, particularly under conditions which exceed the limitations of the gain set alone. For instance, the standard VU meter which is used as an indicating instrument, will give full scale deflection at its most sensitive setting when the power level corresponds to plus 4 dbm in 600 ohms, and measurements cannot be made with the gain set alone on amplifiers which have an output level much below the plus 4 dbm value. These limitations, of which the above is one example, have been overcome by the use of certain setups and procedures which have long been stock-in-trade with the older users of gain sets but which may not be so familiar to newer users of this type of equipment.

Any special methods which are employed should be planned so that maximum independence from frequency effects is achieved and so that the full inherent accuracy of the measuring instrument can be realized. Considering the more stringent requirements specified for FM broadcasting and the general excellence of audio equipment that has appeared since the war, it is highly desirable to be able to measure frequency response with an accuracy of at least plus or minus 0.1 db from, say, 30 cps up to 17,000 or 20,000 cps. Components and instruments presently available should permit measurements approaching this accuracy provided the method used does introduce any compromises.

## Components

The units comprising a transmission measuring set usually follow a general pattern; a typical arrangement for a set having a single VU meter is shown in Fig. 1. The signal-source a-f oscil-

lator feeds into a branching pad which is designed so that a VU meter and its range pot when switched to the "send" side in the upper branch, will correctly measure the level impressed at the input of the variable attenuator in the lower branch. The variable attenuator is composed of a combination of fixed and variable pads arranged so that any loss from 0 db up to approximately 100 db can be inserted, preferably in increments of 0.1 db. The attenuated oscillator signal is fed to the amplifier under test through the "send" jack. Since the input impedance of this amplifier may not be the same as that required at the output of the variable attenuator, an impedance matching network is interposed which is switchable so that a number of different amplifier input impedances can be accommodated at the send jack. The loss in this network will vary with the amount of impedance transformation that is switched in; the amount of loss is usually marked on the network dial. The variable attenuator and the matching network together make up the gain set attenuator, and their losses must be added together to obtain the total gain set loss. The level being sent from the send jack is then equal to the level indicated by the VU meter decreased by the amount of total gain set loss.

The output of the amplifier being tested is connected through the "receive" jack to a load network which will absorb appreciable amounts of power. Again, the receiving impedance can be adjusted to accommodate a number of different amplifier output impedances. Associated with the load network is a meter transformer; when the VU meter is connected to this transformer by moving the VI switch to the receive side, the meter will indicate correctly the amount of power being dissipated in the load network.

## Test Procedure

With a typical measuring set as described above, the basic procedure in measuring the gain and the frequency characteristic of an amplifier (the X-amplifier) will be as follows: Patch the input and output terminals of the X-amplifier to the send and receive jacks, respectively, and adjust the matching

networks to match the nominal input and output impedances of the amplifier. With an a-f oscillator patched into the oscillator jack, the VU meter is switched to the send side and the oscillator signal adjusted to some convenient level. Gain set loss is then introduced until the proper level is being sent to the X-amplifier from the send jack. Then, after running the VU meter range pot up to a high value to protect the meter from possible off-scale readings, the VU meter is switched to the receive side and the output power level of the X-amplifier measured. The gain of the X-amplifier can then be figured since the input and output levels are known. If this procedure is repeated at other frequencies, the complete frequency characteristic of the X-amplifier will be determined. The oscillator level is checked and readjusted, when necessary, to the same value each time, the measurement being in terms of constant input to the X-amplifier. If it is desired to find the frequency characteristic in terms of constant X-amplifier output, the operating steps are essentially the same except that at the first frequency the output level is adjusted to the specified value by varying the gain set loss. Then, after, at the other frequencies, the output level is again checked and adjusted by changing the gain set loss after which the VU meter is switched to the send side and the sending level determined.

Some compromises with maximum possible accuracy in taking a frequency characteristic are incurred in the basic procedure just described. For instance, each determination of gain is not confined solely to reading gain set loss but also includes the operation of reading level with the VU meter. Since the levels are usually different on the send and receive sides, the VU meter range pot will be at different settings in the two cases. Overall accuracy in measurement of gain will be improved if the necessity for changing the range pot can be eliminated; that is, if the levels measured on the send and receive sides can be made identical. Such practice will also improve the accuracy in obtaining frequency characteristics.

\*Station KFI, Los Angeles Calif.

<sup>1</sup>Donald F. Maxwell, "CBS Transmission Measuring Set", AUDIO ENGINEERING, April, 1948, p 16.

<sup>2</sup>A. E. Richmond, "Audio Frequency-response Measurements in Broadcasting", AUDIO ENGINEERING, January, 1948 p 21.

removing possible effects due to change in frequency response through range pot at different settings. It would further result in having the VU meter always indicate at the same place on its scale, thus eliminating other possible inaccuracies inherent in the meter itself. It is to be noted that any further frequency discrimination in the VU meter and range pot is eliminated automatically when the same meter is used for measuring both send and receive levels. Obviously the branching circuit, the meter transformer, and the matching network must be faultless frequencywise. Since requirements on these units are rather stringent when aiming to maintain 0.1-db accuracy in frequency response measurements, it will also be a help if impedances in the measuring setup can be arranged so that it will not be necessary to change the receiving impedance of the load network while testing any one X-unit. It only measures that can be effected to confine the measurement to readings taken only from the gain set attenuator. This tends to improve accuracy since these components are usually more carefully and accurately engineered than the other variable units.

#### Other Restrictions

Aside from the above limitations on accuracy in the basic method, there are no restrictions imposed by the maximum sensitivity of the indicating meter, as mentioned previously. The maximum power that can be delivered to the send jack by the audio oscillator is a further factor. Summarizing, changes in the basic method are indicated in the following cases:

- When better accuracy is desired.
- When the X-amplifier has an input level that is below the sensitivity of the VU meter.
- When the X-amplifier requires a higher level at its input than the oscillator can deliver through the matching pad and gain set attenuator.
- When the apparatus under test has no gain or a loss.

(e) Combinations of the above.

In the following is given a summary of some of the various methods by which optimum accuracy can be realized while measuring the frequency characteristics of X-units having different values of gain or loss and different nominal input and output levels. The method given in each case is usually the one with best accuracy; many other variations are possible when optimum accuracy is not desired. The procedures involve the use of an auxiliary amplifier; they are arranged so that the accuracy of results is independent of the frequency characteristics of this amplifier. Whenever possible the circuits are such that the VU meter measures the same level on both send and receive sides.

The requirements to be met by the auxiliary amplifier are not severe. It need not have large gain; approximately 30 db will be adequate for most purposes. However, its gain should not change during the time needed to make a measurement at any one frequency. The amplifier should be able to accommodate a maximum input level of about 0 dbm; maximum output level need not be greater than about plus 30 dbm (1 watt). Reasonable values of distortion can be tolerated and the hum or noise start level need not be down more than 30 or 40 db below signal at the output except possibly when measuring filters. In that instance better figures for noise or hum and distortion may be required. Inconsistent results will be obtained in measuring any X-unit when there is excessive hum or distortion regardless of where it originates. The auxiliary amplifier should have a number of different input and output impedances to match those in the circuits being measured. Alternatively, minimum-loss pads can be inserted externally as required; the use of pads is also advisable as isolation to prevent possible interaction between input or output transformers in the aux-

iliary amplifier and reactive elements in the filters or amplifiers being tested. It may be that pads will be called for at the input or output of the X-amplifier. In such instances, where they are associated with the unit under test, it is assumed that they will be measured separately with the gain set so that their losses will be accurately known at all frequencies. The transfer switches (SW-1 and SW-2, Fig. 2) can conveniently be lever key switches mounted on a panel with suitable connecting jacks so the test circuit can be completely patched up before the measurement is started.

#### X Units

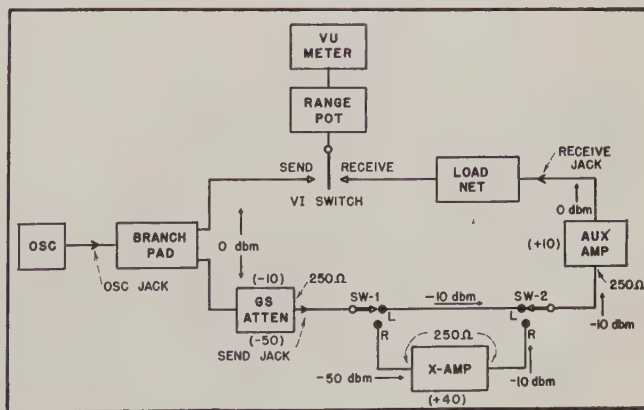
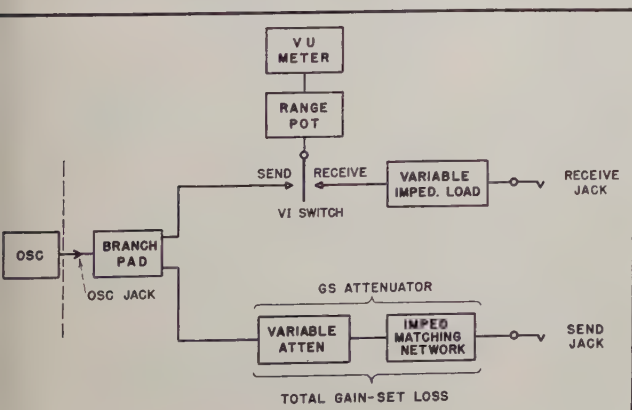
Five general classes of X-units are considered in describing the methods to follow: (1), those with medium gain, low levels in and out (as a preamplifier); (2), those with high gain, low level in and medium level out (as a program amplifier); (3), those with no gain or low gain, medium levels in and out (as a line amplifier); (4), those with medium gain, medium level in and high level out (as a monitoring amplifier); and (5), those with loss depending uniquely upon frequency (as equalizers or filters). Two procedures are outlined for each class, one where the measurement is to be made on the basis of constant input level to the X-amplifier and one for the case where constant output level is to be maintained. Typical values of impedance and of power level at the reference frequency are marked on the figures where pertinent; the numbers in parenthesis are the gain or loss of the indicated unit.

##### 1. Amplifiers with medium gain, low levels in and out.

(A) Constant level into X-amplifier.  
(See Fig. 2.)

Typical constants for this type of amplifier: gain 40 db, nominal input -50 dbm. (See reference 2 for special input circuit if X-unit is a pre-amplifier of the type with so-called open-circuit input.)

Fig. 1 (left). Typical units of transmission measuring set. Fig. 2 (right). Circuit for measuring medium gain X amplifier, low levels in and out.



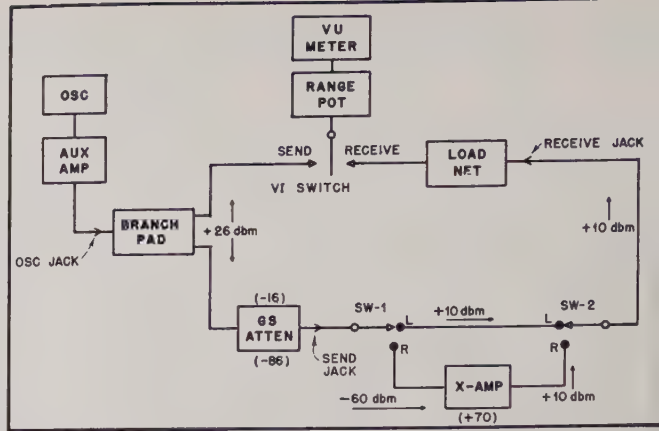
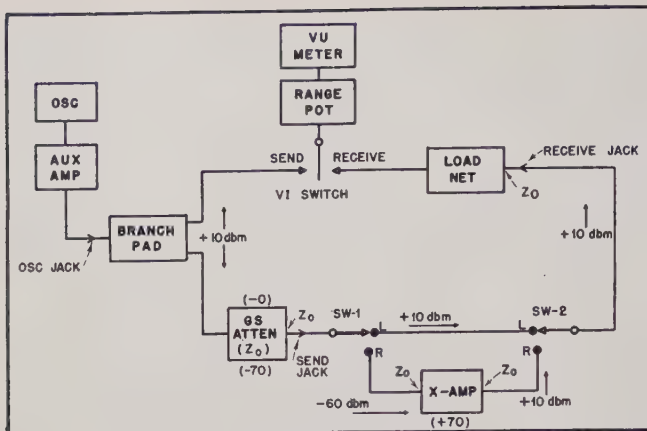
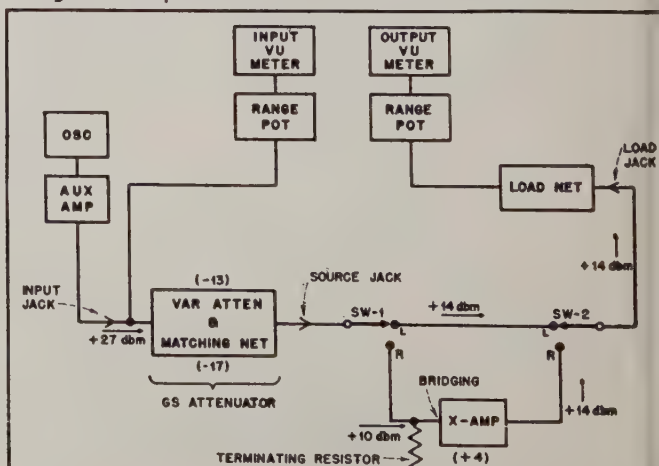
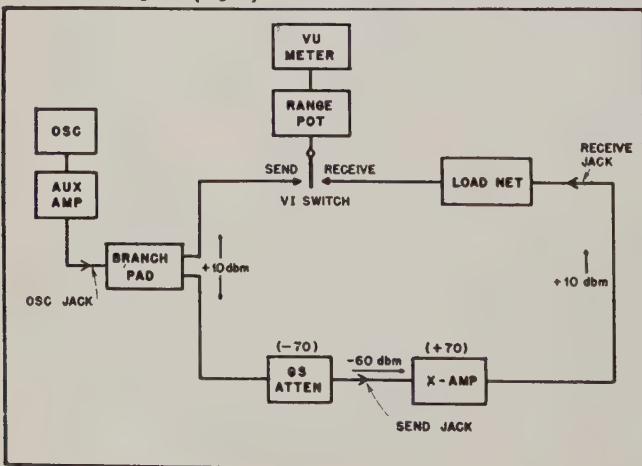


Fig. 3 (left). Circuit for measuring high gain X amplifier, low level in and medium level out, constant input level  
Fig. 4 (right). Alternate for measuring high gain X amplifier, low level in and medium level out, constant input level

- Constant impedances at output of GS attenuator and input of auxiliary amplifier to match those at the input and output of the X-amplifier; it is preferable they all be the same. Insert pads as necessary. (If it is not possible to provide pads to make the impedance alike all around, the next best thing will be to provide a pad at the input of the auxiliary amplifier to match the output impedance of the X-amplifier. Then adjust sending impedance to match input of X-amplifier during steps when switches 1 and 2 are at "R", and to match X-amplifier output when switches are at "L".)
  - With VI switch at send, set oscillator to reference frequency and adjust its output to some convenient level that can be read with the VU meter (say 0 dbm).
  - Set GS attenuator so that known level at the send jack will be the rated input level of the X-amplifier (insert 50 db of loss).
  - With switches 1 and 2 at "R", change VI switch to receive and adjust gain of the auxiliary amplifier until VU meter reading is the same as it was on the send side (0 dbm). Call this the standard VU reading.
- The above steps are to establish the input level to the X-amplifier at the specified level and to calibrate the auxiliary amplifier.
- Change switches 1 and 2 to "L" and decrease loss in GS attenuator until standard VU reading is again obtained. (If the gain of the X-amplifier is exactly 40.0 db, this step will require a decrease in GS loss of 40.0 db; 10.0 db loss remaining.)
  - The gain of the X-amplifier at the frequency will then be equal to the amount it was necessary to change the GS loss in (e).
  - Repeat steps (b) through (f) at the other test frequencies to obtain the complete frequency characteristic of the X-amplifier.
- 1(B) Constant level out of X-amplifier.  
(See Fig. 2.)
- and (b). Same as 1(A) above.
  - Set GS attenuator so that known level at send jack will equal the rated output level of the X-amplifier (insert 10 db of loss).
  - With switches 1 and 2 at "L", change VI switch to receive and adjust gain of auxiliary amplifier until VU meter reading is the same as it was on the send side (0 dbm). Call this the standard VU reading.
  - Insert additional GS loss at least equal to expected gain of X-amplifier (to protect meter against overload), change switches 1 and 2 to "R" and further adjust GS loss until standard VU reading is again obtained.
  - The gain of the X-amplifier at the reference frequency will then be given by the difference in GS losses obtained in steps (c) and (e).
  - Same as 1(A) above.
2. Amplifiers with high gain, low level in and medium level out.  
(A) Constant level into X-amplifier.  
(See Fig. 3.)
- Typical constants for this type of amplifier: gain 70 db, nominal input -60 dbm. The auxiliary amplifier will not be needed if the AF oscillator can deliver a level at the output of the X-amplifier.
- Choose impedance at the receive jack equal to the characteristic impedance ( $Z_0$ ) of the GS attenuator, and insert pads at the input and output of the X-amplifier so an impedance of  $Z_0$  will be seen there also. (One of the steps following requires zero loss through the GS attenuator; this can be obtained only if the attenuator is sending at its own impedance level.)
  - With VI switch at send, set the oscillator to reference frequency and adjust its level and the gain of the auxiliary amplifier until a VU meter reading equal to the rated output of the X-amplifier is obtained.
  - Adjust GS loss so that known level at the send jack is equal to the rated input level of the X-amplifier.
  - Set switches 1 and 2 at "R", change

Fig. 5 (left). Circuit for measuring high gain X amplifier, low level in and medium level out, constant output level  
Fig. 6 (right). Two-vu meter circuit for measuring low gain amplifier, medium levels in and out.



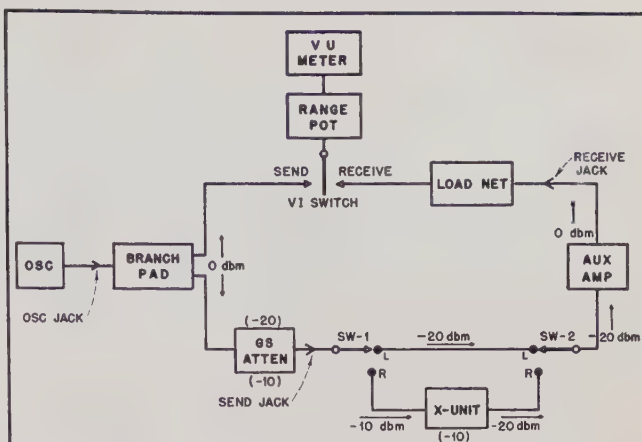
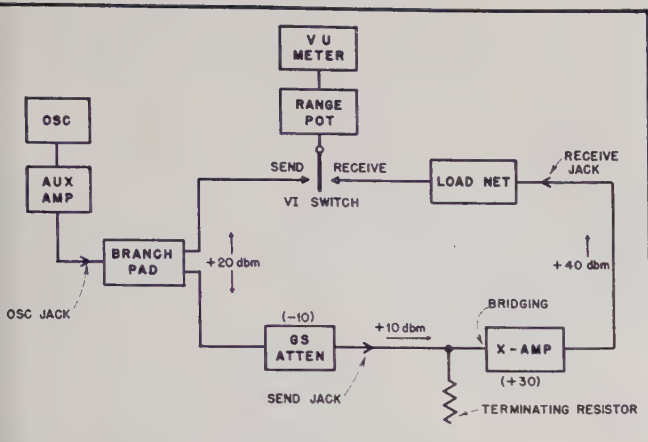


Fig. 7 (left). Circuit for measuring medium gain X amplifier, medium level in and high level out. Fig. 8 (right). Circuit for measuring X units having loss uniquely dependent on frequency.

VI switch to receive and note the output level reading. If it is different from that set up during (b), repeat steps (b), (c) and (d) until the VU meter reads the same on send and receive sides when rated input is being fed to the X-amplifier.

(e) Change switches 1 and 2 to "L" and decrease GS loss until VU meter reading is the same as that obtained when (d) was finally completed.

(f) The gain of the X-amplifier at the reference frequency will then be equal to the decrease in GS loss during step (e).

(g) Repeat steps (b) through (f) at the other test frequencies to obtain the complete frequency characteristic of the X-amplifier on constant input basis.

This procedure is not as straightforward as some of the others but it is the only one known to the writer that gives optimum accuracy (VU meter reading the same at send and receive—measurement depending on GS attenuator only) under this particular set of conditions. An alternate is described below which is more flexible but in which different levels are measured at send and receive positions of the VI switch.

(A). Alternate (See Fig. 4).

(a) Insert pads as required at input and output of X-amplifier to give identical impedances at those points and adjust sending and receiving matching networks to this same impedance.

(b) With VI switch at send, set the oscillator to reference frequency and adjust its output or the gain of the auxiliary amplifier until some convenient VU meter reading is obtained. (The level out of the branch pad should be at least equal to the sum of the minimum loss through the GS attenuator and the maximum level expected at the X-amplifier output at any frequency).

(c) Set the GS attenuator loss so that the known level at the send jack will equal the rated input level of the X-amplifier.

(d) With switches 1 and 2 at "R", change the VI switch to receive and read the resulting output level. Call it the standard VU reading.

(e) Change switches 1 and 2 to "L" and decrease the GS loss until standard VU reading is again obtained.

(f) The gain of the X-amplifier at the reference frequency will then be equal

to the decrease in GS loss during step (e).

(g) Repeat steps (b) through (f) at the other test frequencies to get the complete frequency characteristic of the X-amplifier.

## 2 (B). Constant level out of X-amplifier.

(See Fig. 5).

(a) Choose impedance at the send jack to match the input and at the receive jack to match the output, respectively, of the X-amplifier.

(b) With VI switch at send, set the oscillator to reference frequency and adjust its output or the gain of the auxiliary amplifier until the VU meter reading is equal to the rated output of the X-amplifier. Call it the standard VU reading.

(c) Insert GS loss at least equal to the gain of the X-amplifier, change VI switch to receive and adjust the GS loss further until the standard VU reading is again obtained.

(d) The gain of the X-amplifier at the reference frequency is equal to the final value of GS loss in (c).

(e) Repeat steps (b), (c) and (d) at the other test frequencies to get the complete frequency characteristic of the X-amplifier.

This is one of the simplest of the methods described that still gives optimum accuracy, and is merely a modification of the basic method outlined earlier.

## 3. Amplifiers with low gain, medium levels in and out.

(A) Constant level into X-amplifier.

(See Fig. 6.)

Typical constants for this type of amplifier: bridging input (high impedance); level into terminating resistor at input, plus 10 dbm; level at matching output of X-amplifier, plus 14 dbm.

Variations of Figs. 3 or 4 could be used for this measurement. However, to illustrate the use of the two-VU meter type of circuit, the method for this kind of circuit is described.

(a) This type of X-amplifier is quite often operated with a bridging or high impedance connection at its input, and suitable terminating resistor should be supplied. For instance, if the amplifier is intended for use bridging across a 600-ohm line, then the terminating

resistor should be 600 ohms and the receiving impedance at the load should be set at 600 ohms. Provide pad if necessary at X-amplifier output to make that impedance also 600 ohms.

(b) Set the oscillator to reference frequency and adjust its output or the gain of the auxiliary amplifier until suitable level is read by the input VU meter. (This level should be at least equal to the sum of the minimum GS loss and the maximum level expected at the X-amplifier output at any frequency.)

(c) Set GS loss so that known level at the source jack is the rated input level of the X-amplifier.

(d) With switches 1 and 2 at "R", read the resulting output level with the output VU meter. Call it the standard VU reading.

(e) Change switches 1 and 2 to "L" and decrease the GS loss until standard VU reading is again obtained.

(f) The gain of the X-amplifier through the bridging connection at the reference frequency will then be given by the decrease in GS loss in (e).

(g) Repeat steps (b) through (f) at the other test frequencies to get the complete frequency characteristic of the X-amplifier.

The relative frequency response of the input VU meter and its range pot with respect to that of the load network, the output VU meter and its range pot can be checked with switches 1 and 2 in the "L" position. Set the oscillator to the reference frequency and adjust for any given pair of readings on the two meters. At the other test frequencies, adjust the oscillator level or the auxiliary amplifier gain until the input meter reads the same as at the reference frequency; the output meter reading should then likewise be the same as it was at the reference frequency. The way in which the readings of the two meters track at any one frequency can similarly be checked in a manner obvious to the reader.

## 3 (B) Constant level out of X-amplifier.

(See Fig. 6.)

(a) and (b). Same as 3(A) above.

(c) Set GS loss so that the known level

[Continued on page 37]

# RECORD REVUE

**N**O NEED TO EXPLAIN what a harmonic is to this engineering crew—the readers of this magazine. Little do they know, but most engineers already have the skeleton, at least of the whole principle of harmony and counterpoint, the vertical and horizontal aspects of musical form, though perhaps not quite in the way they may think. Anyone interested in hi-fi (to use a forbidden bit of super-amateur slang!) knows all about tone color, too. That's what you cut off when you cut off. Tone color, of course, is utterly different from harmony and counterpoint—after all, tone color is the frosting on the cake; harmony and counterpoint (melody, if you will) have to do with *pitch*. Tone color is the sound an instrument makes, harmony and melody are the notes that get written down on music paper . . . etc, etc. It is obvious already that if one begins to follow that kind of argument one lands in hot water. And the metaphor is no more cockeyed than the explanations you'll find yourself swimming into, given a good hot discussion as to what is tone color and what is harmony. It's extremely difficult to say.

This peculiar relationship between tone color that changes indescribably (only fascinations of sound as we hear it—because it is part pure physical, mostly pure musical logic, of the brain, completely beyond measuring by any conceivable instrument. (It's that kind of thing that leaves an engineer gasping just a bit, fish-out-of-water-like.) If we hear, for instance, a pure tone of 440 cps, it will sound as an A, so-called. But it will have a lifeless, colorless quality. The addition, perhaps one by one, of harmonics occurring simultaneously with this fundamental will give, for the ear, an increasing tonal color that changes indescribably (only by comparison with knowns can we describe it, unless by formula) as the number and proportions of the various overtones are changed. An electric organ is of course a fine generator of such sounds, and thanks to fixed-position volume controls on each separate overtone, we can mix by formula, up to a point (the organ being a gross simplification of natural sound-mixtures.) All this is simple enough—*except* that, within limits that are very wide, the ear *continues to recognize and interpret the sound as an A—plus varying tone color*. We still hear one, single “note.” We name the whole cluster of tones, the pitch of the “single” tone, from its fundamental: we derive the tone color of this “single” tone from the harmonics, which are, so far as any measuring instrument is concerned, just as much

EDWARD TATNALL CANBY\*

pitch themselves as is the fundamental. (We can even “hear” the fundamental when it is actually absent as is well known. We name the tone's pitch from the fundamental—present or absent.)

So far so good. Nothing very startling about this, to an engineer. But look further. There are, in music, many “tones” present simultaneously a good deal of the time. Chords, some people call 'em. A consonant chord—and we have plenty of them—consists of a fundamental, plus a group of overtones. Thus a chord of C major may consist of a C in the bass, plus C, G, C, E, G, etc., i.e., harmonics numbers 2, 3, 4, 5, 6, etc. Said chord may have six separate “tones” in it, as written on paper.

Now, take your electronic organ, pull out a pure-tone stop, and play these six separate tones simultaneously, as a “chord.” *Listen to it*. Are there six tones, or is there one—plus tone color? That question is unanswerable. It is absolutely impossible to tell. There is, in fact, no possible way to distinguish between “six” tones and “one” tone, given this single combination. Proof of it is that on the electric organ you may actually achieve the sound in two ways, (1) by playing six different keys on the keyboard, (2) by playing one single key and adding the harmonics via the “tone color” stops!

What in the name of blank is a “single tone,” then? The answer is the reason for counterpoint.

A single sound-complex of fundamental-plus-overtone is, musically speaking, much like the sound which we may (as a well-known beer company suggests) variously interpret as TO, TOO, TWO. It depends on the context. And hence the whole conception of melody within harmony. Musicians conceive of chords as collections of melodies, or better, melodic lines, that are vertically related, but which must *move onward*. The study of elementary harmony in music school is largely a matter of “connecting” chords by what is called “voice-leading,” writing chords in such a way that each “voice” or melodic line moves logically and with independence from one chord to the next. The reason for this is never made any too clear in music teaching, probably because few musicians know why. It is just “good musical practice,” like clean wiring in a sound system. But at this point the engineer reader can see what few musicians understand, that the reason we

musicians are so concerned with movement of melodic lines in a piece of music, the reason why we base almost everything on the way such lines move, simply that *if they didn't move they would disappear—become overtones, much tone color!* And that is probably the most profound statement, quite seriously, that this column has ever indulged in.

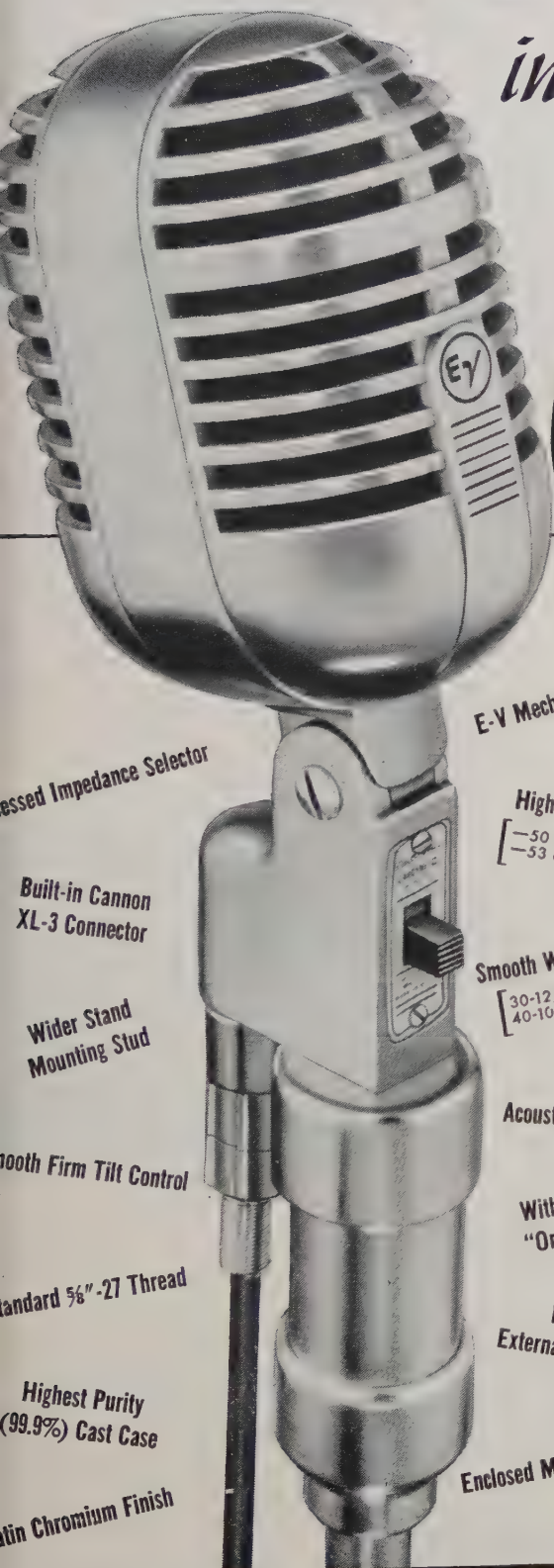
As soon as music begins to move, it begins to live. And nine-tenths of the life is in melody, in the horizontal series that successive single tones can make in the brain. Thanks to melody, the distinction between tone color and actual harmony (collections of separate, though related, tones) is perfectly clear to the mind. And the distinction being clear, there are multitudes of subtleties to be made use of, involving the two things. A pipe organ is a fascinating case in point—for there, in actual musical practice, a single written note is played by numerous different and distinct pipes, in the various stops—the combined sound of the pipes being *interpreted by the ear* as a single tone plus tone-color harmony. This interpretation, again, depends entirely on the melodic movement which keeps each separate tone in the written music alive via motion.

The same principle, for that matter, is used even more extensively in the orchestra. In orchestration we speak often of “real parts.” By that we mean single melodies again—for when an orchestra of some hundred players gets going full blast, there are not, as you may imagine, one hundred separate melodies! Instead there may be four, perhaps a few more “real parts.” The sound that the orchestra makes consists largely of tone color; each of these real ear-melodies may be played by a whole group of differing instruments simultaneously—yet, as the ear gets it, it remains *one melody*. The purpose of the extra instruments, then, is to add tone color to the fundamental pitch (which can ignore for the moment the consideration of rhythm).

Even the piano, in some styles of music, may be used in the tone color way. Debussy, for instance, often writes single melodies that, on the piano, are played by whole handfuls of notes—what look like chords. But they aren't really chords, because the motion is what we call parallel; that is, all the notes move as though locked together. Though some might argue differently, it seems fairly clear that these tone-clusters, moving along together, are simply melodies with an unusual tone color. In any case, the distinction, again, is entirely in the motion of the music.

[Continued on page 40]

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# NEW PRODUCTS

## CINE MOTOR

A new variable speed motor with tachometer for the 16 mm camera field to fit the Cine Special and Maurer cameras has been developed by the National Cine Equipment, Inc., 20 West 22nd St. New York City.

A professional type motor, designed for complete versatility, compactness, economy and interchangeability. A speed range of 8 to 50 frames per second, variable speed, determined by the mechanical governor and read on the bold faced tachometer for the 16 mm camera field to fit facing the cameraman for easy reading and operation.

Basic unit of motor, consisting of separate base for Cine Special camera, with interchangeable motor as follows:—

115 Volt AC-DC, Universal, Variable speed with Tachometer.

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115 Volt, 60 cycle, AC Single Phase, Synchronous.

220 Volt, 60 cycle, AC, Three Phase, Synchronous.



For use on the Maurer camera a special adapter plate is attached to the camera and any of the above motors can be used.

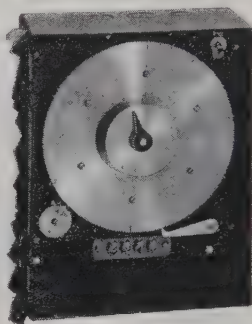
The 115 volt Variable Speed motor can be used on house current or light weight batteries as used in the Motion Picture industry for location work. The 12 volt motor is battery operated with batteries obtainable complete with self contained charging units.

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## TIMERS CONTROL AUDIO PROGRAMS

Montgomery Mfg. Co., 549 West Washington St., Chicago 6, Ill., announce their new line of synchronous program timers that are particularly suited for accurate

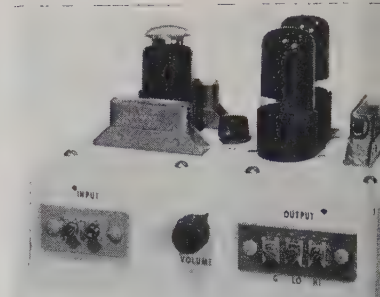


control of public address, radio, chimes or any system of wired or direct reproduction. These units can be set exactly for the time of day programs are to be switched on and off with any desired interval as low as two and one-half minutes. As many as 288 operations per day can be set on the program disc. A calendar switch is provided which can be set to silence the program through as many twelve or twenty-four hour periods as desired in any week. Thus a single operation or a full week's program can be set up on the timer which will be continuously repeated until reset. With these low-cost program timers, sound engineers can inexpensively control audio programs in industrial, commercial and educational institutions.

## CUEING AMPLIFIER

The Fairchild Recording Equipment Corporation has now made available a cueing amplifier for transcription turntables. Its purpose is to provide a local audio signal for monitoring or cueing. Using push-pull stages and inverse feedback, the amplifier, known as Fairchild Unit 635-A2, has a frequency response of 70-15,000 cps,  $\pm 1\frac{1}{2}$  db.

The amplifier will supply 3 watts of audio to a loudspeaker. A wide choice of



voice coil impedances is available. A impedance output is also provided feeding one or more headsets. A former input of 10,000 ohms impedance permits grounded or ungrounded bridge across any low impedance line without reflecting a mis-match. The cueing amp is quite small, 7" x 6" x 4½", and mounts readily in a minimum of space.

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First phonograph records and reproducing instruments to be designed specifically to complement each other, RCA Victor developments offer not only high in reproduction quality at low cost but also the first single-size disc (under 7 inches) for all classification of recorded music—popular, classical, and children's material. Operation at 45 rpm provides up to 5 minutes and seconds of playing time on each side of the small, vinyl plastic records, or up to 12 minutes when eight records are stacked on the automatic record-player, which is said to contain the fastest recording-changing mechanism ever devised.

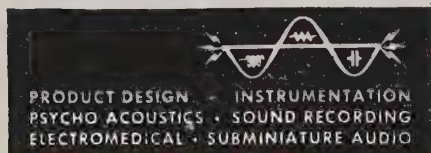
[Continued on page 50]



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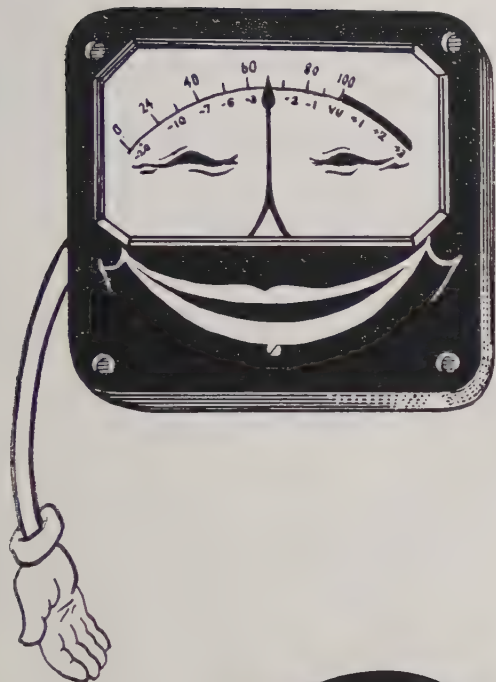
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*\*Volume unit meter commonly used for measuring sound level in audio systems*



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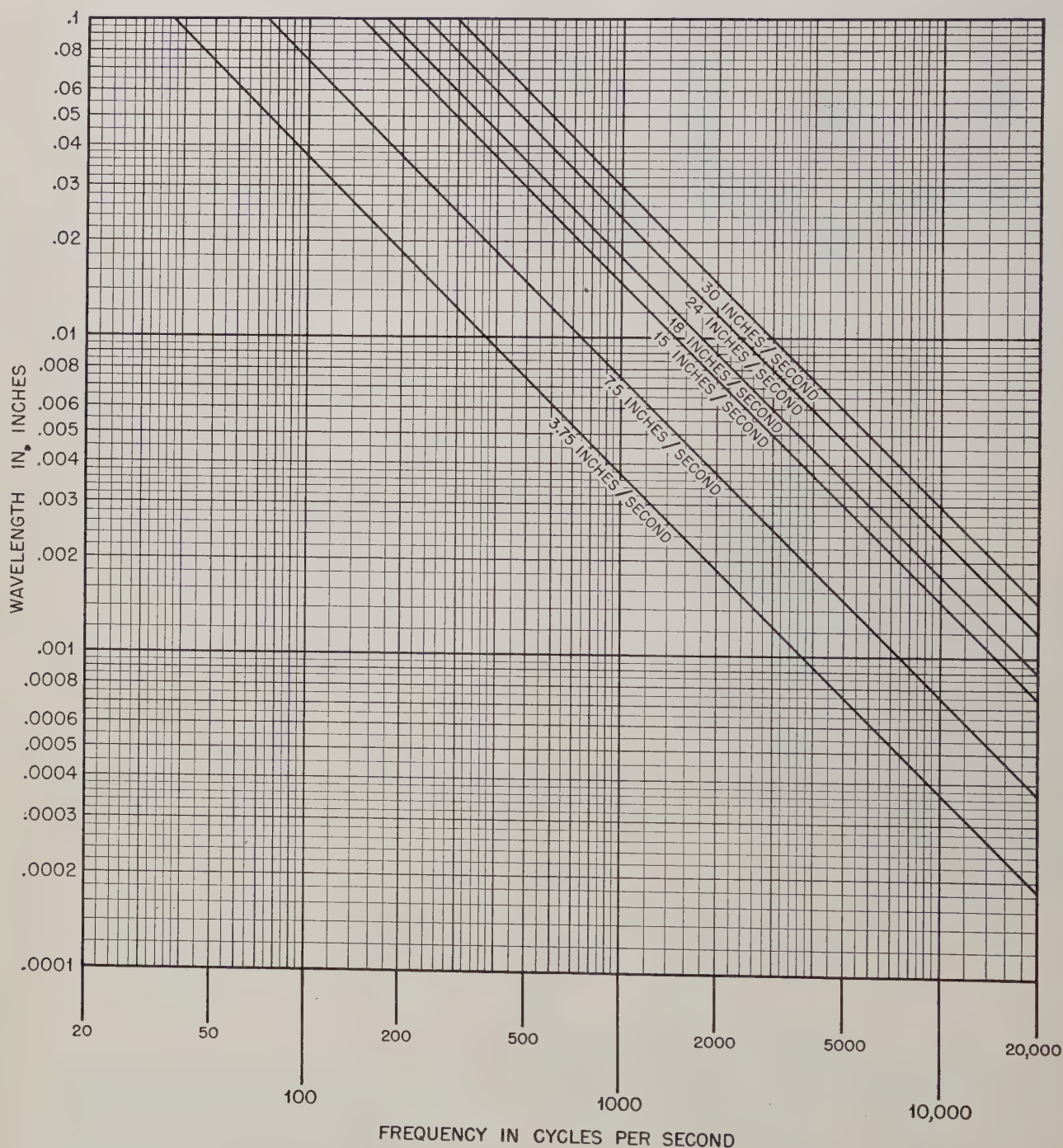
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# AUDIO DESIGN NOTES

## MAGNETIC TAPE OR WIRE SPEED VS. RECORDED WAVELENGTH



"STYLUS"

## Audio Development Appoints Hanson

The addition of Robert M. Hanson as chief engineer to its engineering department has been announced by the Audio Development Company, Minneapolis, Minn. Mr. Hanson comes from the Thordarson Electric Company, Chicago. As chief engineer for that company, Mr. Hanson has made many friends throughout the country. He was associated with Thordarson for twelve years.

The appointment of Mr. Hanson to Audio's staff will relieve vice-president Walt Lehnert to devote more of his activities to new developmental and research programs for the purpose of improving and increasing the technical transformer services of Audio Development Company.

## LETTERS

[from page 4]

piece deserves a Hyper Quadra and anything less won't do!"

With personal knowledge of the amplifier's performance, the equalized phono and radio, all coupled to the glamorous H.Q., try and tell our friend he hasn't realized Truth! But he may be an exception. After the initial creator's thrill has faded, he may heretically wonder if this thing sounds right.

Let us temporarily digress to a pertinent philosophic issue. Many of us have musical talents and an excellent ear for relative pitch. A few (very few) of us have the same talents plus an absolute pitch ear. Accurate pitch can be measured and corrected for, by turntable speed variation. How to measure the faithfulness of instruments, voices, noises, and other sounds for relative tonal content balance as it hits the ear? How many of us have an absolute tonal balance ear?

There seem to be ears which apparently approach an absolute tonal balance calibration or retentivity. Witness the letter from a man who says that most electro-acoustic sound exaggerates frequencies between 2 and 4 kc. Compared to the absolute (source) he hears an excess of "middle highs." If objective unglamorized measurements on the H. Q. show a five or so db "bulge" in this range, wouldn't this indicate the possible cultivation of a potentially absolute ear?

If you're a sound absolutist, how does your ear rate? Do you hear in terms of absolute or relative tonal balance? By now you may suspect, and rightly so, that without objective and detailed data on your speaker system, you cannot, as a scientist, claim Truth. Further, assume our hero gets the speaker data. Does he have the knowledge and practical wisdom to evaluate and interpret all the angles in terms of creating Truth?

How is he to learn about his objectives



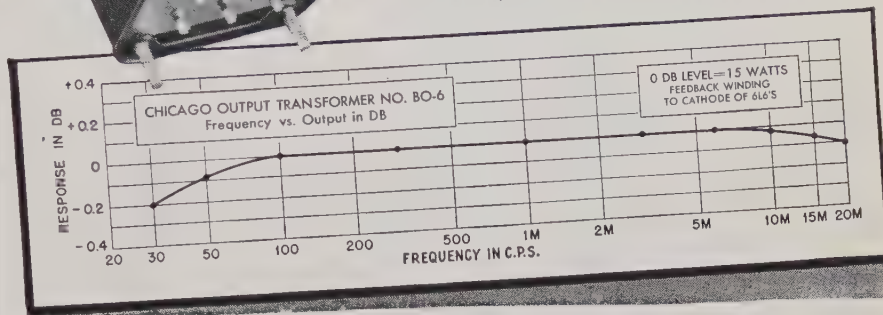
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BO-3	P.P. Plates to Line	Pri.—5,000 ohms CT *Sec.—600/150 ohms CT	+40 dbm	17.00
†BO-4	P.P. Plates to Line	Pri.—7,500 ohms CT *Sec.—600/150 ohms CT	+43 dbm	18.00
BO-5	P.P. Plates to Line	Pri.—10,000 ohms CT *Sec.—600/150 ohms CT; 16/8/4 ohms	+37 dbm	24.00

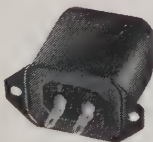
†Tertiary winding provides 15% inverse feedback. \*Split and balanced windings.

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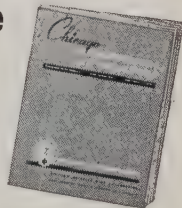
No.	Inductance	List
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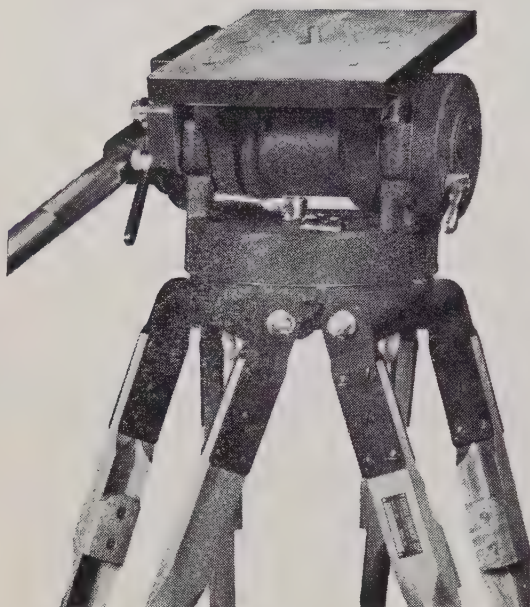
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in terms of response versus polar characteristics, subjectively apparent source size, low frequency damping, optimum baffling, optimum electrical and space phasing in multi-channel reproducers, and cabinetry diffraction effects?

Art calls for a cultivation of certain sensory perceptions. We introduce art when we begin to evaluate sound as we hear it coming from an electro-acoustic system. Maybe the relativists have something when they quit trying to re-create sound, and bend their efforts on "improving" it.

The obstacles to reaching Truth are augmented by microphone techniques, and some despots of the source at radio broadcasts and at recording manufacturers.

For the sound relativist, I've offered the "Universal New Sound Hearing Aid." The absolutist with a relative tonal ear has my sympathy. The absolutist with a potentially absolute ear is urged to attend live shows and concerts—listening with a deliberate consciousness to the tonal balance. Let him imagine his Masterpiece up front and judge if the sound he hears is compatible with the system. Then, don't build a new amplifier. Instead, listen with a jaundiced ear to the heretofore paragon—the Hyper Quadra.

Bruno Staffen,  
4435 So. Talman Ave.  
Chicago 32, Ill.

## TRIODE AMPLIFIER

[from page 10]

### Tests

The intermodulation curve of Fig. 3 was taken with the Pickering analyzer, using input frequencies of 100 and 7000 cycles at 10 decibels difference in level. Total harmonic distortion analysis gave reading of  $\frac{1}{3}$  to  $\frac{1}{4}$  the numerical values of the IMD figures, at corresponding powers.

The frequency-response curve of Fig. 2 is a power line, based on 30 watts, and is therefore of significance at much more than usual operating levels. The low-frequency drop is attributed to output-transformer core-saturation.

Noise level was measured with a shielded 100,000 ohm resistor across the input terminals, with the gain control wide open. Further amplification of the output was required to distinguish its character audibly. It was the usual random hiss superimposed upon a lower level of hum. The absolute level of noise at the output under these conditions was -52 dbm, or nearly 96 decibels below the nominal 30-watt output level.

Effective internal impedance at the 15-ohm tap is 6 ohms.

Thirty watts of output was reached with about 0.1 volt drive, giving a nominal 85 db maximum gain.

Although all the tests indicated that the amplifier was suitable for its pur-

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poses, the final judgement would have to be that of prolonged listening by critical people. The nature of the distortions which offend a "golden ear" still defies analysis, but whatever their causes these offenses had to be excluded from the present amplifier if it were to be useful. The operation was apparently a success, for the equipment was later used with laboratory-produced transducers capable of accurate reproduction of sounds in the 20,000 cycle area without pain to the perhaps hypercritical listening of the speaker-creators. Prolonged use has confirmed the original opinion that the amplifier is contributing no unpleasantness. Its low internal impedance is audibly an effective damp on oscillatory excursions of bass speakers employed with it.

For all of the excellent characteristics obtained here, no fuel is meant to be added to the fire of academic argument over triodes and beam tubes. The high-frequency equipment mentioned above has been used with beam amplifiers employing ample feedback with no decrease in listening satisfaction. It is believed that the requirements met by the present amplifier could have been reached equally well, and at lower cost, with beam tetrodes using generous feedback.

## MEASURING SET

[from page 29]

at the source jack is the rated output level of the X-amplifier.

- (d) With switches 1 and 2 at "L", read this output level with the output VU meter. Call it the standard VU reading.
- (e) Insert additional GS loss at least equal to the gain of the X-amplifier, change switches 1 and 2 to "R" and further adjust GS loss until standard VU reading is again obtained.
- (f) The gain of the X-amplifier through the bridging connection at the reference frequency will then be equal to the difference in GS losses obtained in (c) and (e).
- (g) Repeat steps (b) through (f) at the other test frequencies to get the complete frequency characteristic of the X-amplifier.

### 4. Amplifier with medium gain, medium level in and high level out.

- (A) Constant level into X-amplifier.  
(See Fig. 7.)

Typical constants for this type of amplifier: bridging input (high impedance); level into terminating resistor at input, plus 10 dbm; level at matching output of X-amplifier, plus 40 dbm.

- (a) Provide termination with resistance equal to impedance of line across which the bridging input of the X-amplifier is intended to work and set sending impedance to same value. Set receiving impedance to match X-amplifier output.
- (b) With VI switch at send, set the oscil-



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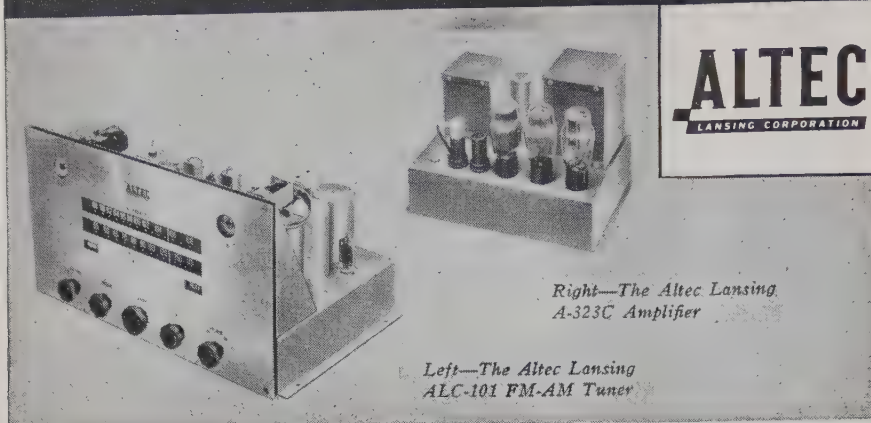
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Left—The Altec Lansing ALC-101 FM-AM Tuner

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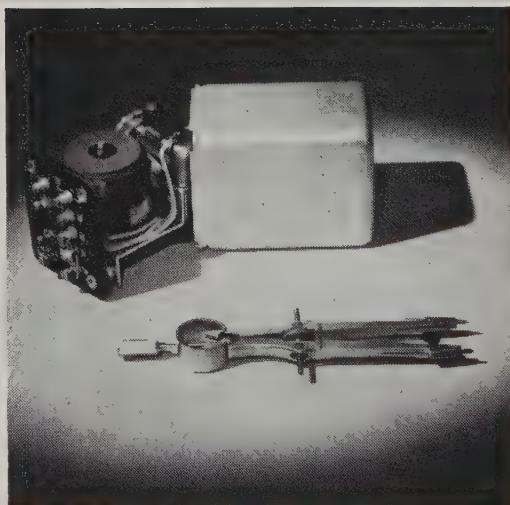
bination is available with special accessories to permit rack mounting for professional monitoring. Phonograph and television inputs and required switching are provided.

Technical folder describing ALC-101 Tuner and A-323C Amplifier sent on request. Write Altec Lansing Corporation, 1161 North Vine Street, Hollywood 38, Calif., 161 Sixth Avenue, New York 13, N. Y.

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lator to reference frequency and adjust its level or the gain of the auxiliary amplifier until some suitable VU meter reading is obtained. (The level out of the branch pad should be at least equal to the sum of the minimum loss through GS attenuator and the level required at the terminating resistor.)

- (c) Set the GS loss so that the known level at the send jack is equal to the rated input for the X-amplifier.
- (d) Change the range pot so as to give protection to the VU meter, move the VI switch to the receive position and read the output level.
- (e) The send VU reading in (b) minus the GS loss in (c) gives the input level to the X-amplifier; the receive VU reading gives the output level. Their difference gives the X-amplifier gain at the reference frequency.
- (f) Repeat steps (b) through (e) to get the complete frequency characteristic of the X-amplifier.

This is another case where it is difficult to obtain optimum accuracy. It is difficult to maintain identical levels on the send and receive sides of the VI switch because of the high output level normally obtained from this class of X-amplifier. No advantage in this respect would be gained by using a two-meter type of circuit such as that of Fig. 6, unless it could be determined by other means that the frequency responses of the load network and of the two meters and their range pots were flat to within the desired accuracy. This cannot be tested directly and appropriate corrections applied, if necessary, as was possible with the method of Fig. 6 where X-amplifiers with lower output level were being measured.

Of course, if desired, a pad which would withstand the plus 40 dbm could be built, measured separately, and then inserted at the output of the X-amplifier so as to reduce the level at the receive jack to the point where the levels on the two sides of the VI switch could be made the same. One of the more accurate methods described previously could then be used to measure the frequency characteristic of the pad and X-amplifier in combination.

4(B) Constant level out of X-amplifier. (See Fig. 7.)

- (a) and (b) Same as 4(A) above.
- (c) After changing VU meter range pot to protect the meter, move the VI switch to receive and adjust the GS loss until rated output is obtained from the X-amplifier.
- (d) and (e) Determine gain of X-amplifier at the reference frequency as in (e) of 4(A) above; get complete frequency characteristic as in (f) of 4(A) above.

5. Units having loss uniquely dependent on frequency.

(A) Constant level into X-unit. (See Fig. 8.)

Typical constants assumed for this type of X-unit: maximum level in —10 dbm; loss at reference frequency 10 db.

- (a) Insert pads as necessary at input and output of X-unit to give identical im-

pedances at those points; adjust sending network and auxiliary amplifier input to these same impedances.

- (b) With VI switch at send, set oscillator to reference frequency and adjust its output to some suitable level. Call it the standard VU reading.
- (c) Set GS loss so that known level at the send jack will be that desired at the input of the X-unit.
- (d) With switches 1 and 2 at "R", change VI switch to receive and adjust gain of the auxiliary amplifier until standard VU reading is obtained.
- (e) Insert GS loss at least equal to the loss in the X-unit, change switches 1 and 2 to "L" and further adjust GS loss to again give standard VU reading.
- (f) The loss of the X-unit at the reference frequency will then be given by the difference between GS loss in (c) and that finally obtained in (e).
- (g) Repeat steps (b) through (f) at the other test frequencies to get the complete frequency characteristic of the X-unit.

(A) Constant level out of X-unit.

(See Fig. 8.)

It is not likely that an X-unit of this type will be tested while maintaining constant level at the output but if it is desired to make such a test the method, which will be similar to that of 1(B), is at this point undoubtedly obvious to the reader.

## LOUDNESS CONTROL

[from page 25]

The ground circuit of the amplifier. The finished control should then resemble that shown in Fig 1(A). Input connections to the control are made at points 0 and 23, and the output connections to the arm lug and point 23, the latter being the common or grounded side.

### Installation

The loudness control may be installed between the existing volume control of any amplifier and the following grid, or it may be installed in place of the present control. It is necessary, however, that the overall gain be adjusted so that normal room volume is at about step 4 of the control. This allows some 8 or 10 db above normal for demonstration purposes, or for those occasions when such an increase is desirable, and some 40 db of range below the normal for late evening listening or for background use.

It will take some time to become accustomed to this control because the average listener fully expects the quality to change as the level is raised or lowered. Since no apparent change in *quality* is encountered, it may seem that the level is not changed, but after a week's use it is almost certain that the listener could not go back to a simple volume control. Even at very low levels, the quality remains constant, giving



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It will be observed that the switch has discrete steps, with the detent action. If this should prove objectionable, the detent may be removed by spreading the flat retaining spring out slightly and allowing the steel ball to drop out, thus giving a continuous smooth action. In addition, this permits the shorting-type arm to shunt two contacts, reducing the level difference between points. Personally, we prefer the step-type

control, but it is purely a matter of choice.

#### The Decompensator

On speech, particularly male, the loudness control may appear to be too bassy, and some means for reducing the compensation may be desired. The logical method for this is to short out the compensating capacitors progressively from the high end down. This may be accomplished with the "G" switch deck, with the shorting arm cut in half, and with the normal arm removed. To make

the ground connection, it is also necessary to short the grounding ring to the arm contact on the bottom of the rotor. This may be done by adding another rivet between the two rings. The modified switch is shown in Fig. 1(B). In this photo, the rotor is shown in the maximum clockwise position, corresponding to normal compensated operation. The six lugs opposite the rotor ring are connected to the junctions of the six 0.15-meg resistors and the .005- $\mu$ f capacitors, so that as the decompensator is turned counter-clockwise the capacitors are shorted to ground. In the position shown, all six contacts are open; in the second position the capacitor associated with point 4 is shorted; in the third position, the capacitors for points 4 and 7 are shorted; in the fourth those for points 4, 7, and 10 are shorted, and so on. The stop is set to provide a total of seven positions, the .0075- $\mu$ f capacitor remaining in the circuit at all times, since the switch will accommodate only six shorting positions.

With the construction of the loudness control reduced to such a simple procedure, it is expected that many experimenters will find it worth the hour or so of work necessary to try it out because of the enjoyment certain to be obtained. The writer firmly believes that no listener will ever give up the loudness control after using it for a few weeks—it's that good.

## RECORD REVUE

[from page 30]

Melodies in plain octaves (fundamental plus harmonic number 2) are of course extremely common on the piano and everywhere else. More complex clumps of tone color that move as melodies are common enough, especially in contemporary music.

A final filip to all this: it may now be understood that the more tone color an instrument has by nature, the more clearly will a melodic line played by it stand out and separate itself from the tentacles of those overtones that wish to swallow it up as so much tone color to the bass. Its own natural harmonics tend to fight against those of the fundamental; the ear as a result hears it stand out in relief against the background. All orchestration is based on the know-how a composer has, as to what will blend (accompaniment) and what will stand out. An amateur writer for orchestra (I've tried it) is likely to hear his principal melody vanish completely, his accompaniment stand out in front, thanks to injudicious use of the power of tone color (a good paradox) to aid melody! Intensity is of surprisingly slight importance in these re-



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spects—a very low-level sound may cut cleanly through a whole orchestra of accompanying melodies, if its tone color is right. Needless to say, the same principle guides the organist in choosing his pipes—not volume, but tone color.

Counterpoint, the special science of combining melodic lines to move along together, is then an absolutely fundamental discipline in all music, for as it now, I hope, is clear, music is very largely a constant struggle against the power of the fundamental to swallow up its own overtones. To return to the opening analogy, if music is to keep afloat against this power of harmonic gravity, the tremendous pull of the bottom, it must *keep moving*.

#### Recent Recordings

Liszt,

Sonata in B minor; Shorter piano pieces. Gyorgy Sandor, piano.  
Columbia LP  
ML 4084 (1)

Beethoven,

Symphony No. 1. New York Philharmonic, Bruno Walter. Columbia LP  
ML 2027 (1-10")

Most of the LP records now appearing are understandably reissues of familiar recordings from the past few years—all, of course, are pre-war, no later than 1947. Columbia releases one or two "new" ones each month, of which the above are samples. Since they are also available on standard shellac, the contrast is interesting. The Liszt sonata is a big, foreboding piece, with many dramatic loud parts, but (as played in concert) even more dramatic silences and very low-level passages. On shellac these are badly obscured and undramatic, thanks both to the pounding 78 rpm rhythm and the hiss of which it is a part. The very opening notes of the music, extremely soft, practically disappear. On LP the clarity and effectiveness of these low-level passages is strikingly enhanced. And, needless to say, the continuity, the whole sonata (one-movement) on a single long side, is of great help.

The Beethoven first symphony, a beautifully made work, compact, good humored, is neatly and pleasantly scaled to the ten-inch record, two movements to a side. Walter is one of the top conductors for this type of music. If you like the Prokofiev Classical symphony, this one will probably suit you well.

Baroque Trio Sonatas (Loeillet, Telemann).

Alfred Mann, recorder; Edith Weiss-Mann, harpsichord, Lois Wann, oboe; Ernest White, organ. Technichord  
T-13 (4-10")

This is probably the first time in this country that the older ensemble music of this type has been recorded with modern wide range technique, and the results are enjoyable. The trio sonata is a form in what most of us would call the "Bach style" (or Handel) in which three elements take part, three "parts" or "voice," the bottom one having along with it, just as in today's popular and folk music, a chord accompaniment that is more or less improvised to fit the harmony. The variety of tone color is immense—some trio sonatas are for organ alone, with two keyboards and the pedals making the three elements; the sonatas in this album combine the contrasted tones of the recorder (no—not a recording machine, but a flute with a whistle-type mouthpiece) and the oboe against the harpsichord and/or organ. One sonata features the harpsichord as

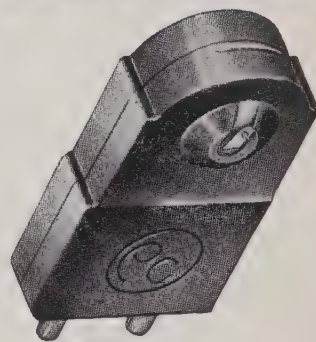
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leading solo, the organ as accompaniment, and the recorder, on top, as a third member. Extremely difficult balance problems have been remarkably well solved, though at times the harpsichord seems too close.

Beethoven,  
An die Ferne Geliebte (song cycle).  
William Horn, tenor, Franz Rupp,  
piano.

Mercury  
DM 8 (2-10")

Cimarosa  
(arr. Benjamin), Oboe Concerto.  
Mitchell Miller, Saidenberg Little  
Symphony.

Mercury  
DM 6 (2-10")

Two more short additions to the catalogue of Mercury single-mike recordings, and both will be of interest to technicians who wonder how far one can go with this method and still avoid "off-mike" effects and excessive reverberation. The answer, in the oboe work, is 30 feet! That's the distance from mike to oboe. (But don't just try it any old place—the studio must be just so.) The Beethoven, I'd say, is not as successful technically. I like it, and the piano is better than most U. S. piano recordings; but there is a distinct off-mike effect—perhaps merely because of our habitual hearing of very close mike pickup. Decidedly *not* a poor recording—but on these highly technical grounds, a challenging one. The oboe concerto, arranged from keyboard pieces, is sprightly 18th century music, beautifully, suavely played. The Beethoven, his only song cycle, will please anyone who is attuned to the special kind of music called "lieder," or "art-song," with unpleasant connotations that the music doesn't deserve.

I Can Hear it Now. (1933-45)  
Compiled by Ed. R. Murrow and Fred  
Friendly. (CBS)

Columbia  
MM 800 (5)  
LP: ML 4095

This is the first documentary type recording to achieve wide popularity, as it evidently has. It uses radio-movie techniques, was patched together on tape, represents a technical milestone in recording, even if the same technique has been used extensively on the air for some time now. Running comment, with dubbed-in excerpts from famous speeches, occasions, etc. some of it used as background. Enormously boiled down from a huge mass of material, and it shows it some—excerpts are too short, in most cases; often just a few words. Due to poor quality in most originals (how remarkably poor the recording done in the early 1930's sounds now!) the quality of the tape job can't be accurately measured here. Spoken commentary is wide range, very clear.

Music for Films.

(Excerpts by Gray, Rosza, Vaughan  
Williams, Spoliansky.) Queens Hall  
Light Orchestra, Williams. Philhar-  
monia Orchestra, Irving.

Columbia  
MM 794 (3)

This is fine background music, and so film-like that you'll think you're seeing movies when you hear it. Pretty feeble stuff as pure music—but then, is it supposed to be pure music? In any case, speaking technically, there is one interesting point: the Queens Hall orchestra is recorded with popular-style technique, evidently a lot of accentuation, probably numerous mikes. The Philharmonia is

given straight classical treatment (European style). Both have good range, excellent general acoustics, but, played next to each other, the techniques are rather strikingly different in effect. Much more detail, a lighter feeling to the Queens records, bigger, heavier feeling, at-a-distance, to the Philharmonia. Orchestras themselves are probably very much alike in size and composition. The Vaughan Williams (he's a "straight" composer of high rep, too) is the best stuff; moody, for a tragedy in the film, heavy-handed, ominous.

Bartok,

Concerto for Orchestra (1943).  
Pittsburgh Symphony, Reiner.

Columbia  
MM 793 (6)  
LP: ML 4102 (1)

This is a tremendous, Beethoven-like work, muscular, full of fire, built large, yet in many spots highly humorous too. It's late Bartok, and so it is anything but difficult to listen to. You'll find that it has a rather normal symphonic sound, over-all, with the details often highly dissonant. Moods are clear-cut, contrasts violent. For the technician this is a splendid example of fine recording of large-scale music, not unlike the superb Mahler symphonies recorded by the New York Philharmonic under Bruno Walter (Audio Engineering, June '48). Big, brassy effects, drums, etc. The LP version is particularly useful, with so many sides involved in the shellac. Note, though, on the LP some prime examples of groove side wall distortion—a sudden loud peak is heard clearly the turn before it arrives. A minor penalty for LP's length. (But such violent changes in dynamics occur only occasionally in music and this kind

## It's Tops!

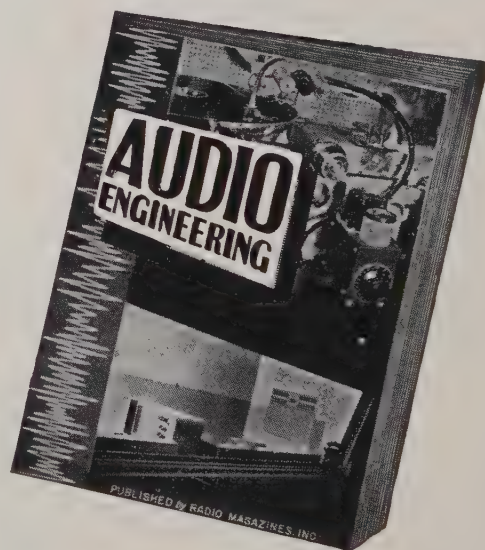
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of distortion doesn't do much harm in the large.)

Mendelssohn,

Midsummer Night's Dream Music.

N.B.C. Symphony, Toscanini.

RCA Victor

DM 1280 (4)

Dvorak,

Symphony No. 5 ("New World")

Leopold Stokowski and His Symphony Orch.

RCA Victor

DV 25 (5 pl.)

Two standard works brought technically forward with new and better recording. Of the two the Stokowski is far and away superior in recording technique. Stokowski has always made much of his interest in the technical side; whether he or someone else is responsible, there's no doubt that his fancy experiments in mike setting give results. Compare this with his own reading of the same music in a pre-war Columbia album (CM 416) with the All-American Youth Orchestra—same interpretation, more or less, but a most extraordinary difference in presence and realism, over and beyond the wider tonal range. The Toscanini Mendelssohn is, contrary to some earlier NBC Symphony recordings, too live. Or let us say, the liveness is miscalculated; it is the type that confuses the music, gives a thinnish, flat sense, instead of a big, roundness. And this with a perfectly good tonal range. Musically, Stokowski's Dvorak is what the music needs; Toscanini's Mendelssohn is all a musician could ask for, but some listeners would prefer an even more sentimental version of this sentimental music.

(NOTE: The Victor 45 rpm record, the competing Columbia 7" LP record at 33 1/3, the Mercury 1 1/2 hour LP record, playing on Columbia equipment, the Concert Hall Society LP record, all are scheduled to appear just after our press deadline! Comment in detail on these epic announcements and on the technical war about to begin will appear in this column and elsewhere in the magazine in the coming issues.)

## 1949 I.R.E. National Convention

March 7-10, 1949

**T**HE 1949 National Convention of The Institute of Radio Engineers will be held from March 7 to 10 at the Hotel Commodore and Grand Central Palace in New York City. Since so much of modern life and living is based upon electronics, "Radio-Electronics—Servant of Mankind" will be the theme of a program combining technical sessions, social events, and manufacturers' exhibits.

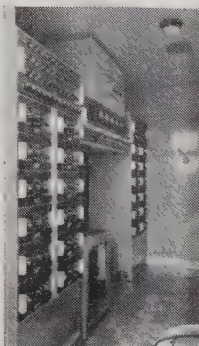
The technical program will feature twenty-seven sessions on subjects embracing virtually the entire radio-electronic art, and six symposia, on nuclear science, network theory, electronic computers, radio aids to navigation, semiconductors, and marketing.

The annual meeting of the Institute will start off a social program high-lighted by three events, the get-together cocktail party, the luncheon to honor the IRE's incoming president, Stuart L. Bailey, and the annual banquet.

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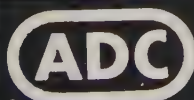
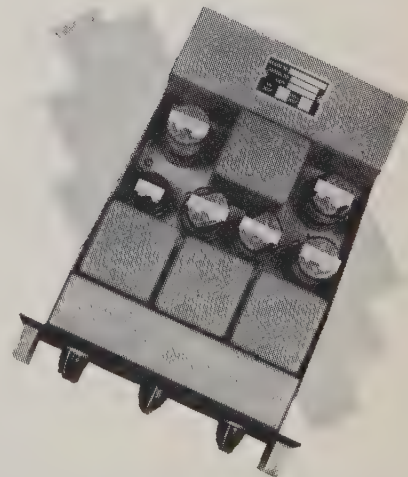
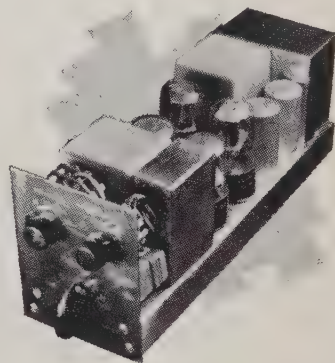
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war research will be presented at Grand Central Palace.

The following papers are to be presented during the technical sessions:

**Monday Afternoon, March 7, 1949**

**Systems I - Modulation Systems**

"Development of a High Speed Communication System"—*Donald S. Bond*

"Distortion in a Pulse-Count-Modulation System with Nonuniform Spacing of Levels"—*P. F. Panter and W. Dite*

"Cross-Talk Considerations in Time-Division Multiplex"—*S. Moskowitz, L. Diven, and L. Feit*

"Experimental Verification of Various Systems of Multiplex Transmission"—*D. R. Crosby*

"Interference Characteristics of Pulse-Time Modulation"—*E. R. Kretzmer*

"Factors Involved in the Design of an Improved Frequency-Shift Receiving System"—*Colin C. Rae*

**Antennas I**

"Some Properties of Radiation from Rectangular Waveguides"—*J. Bolljahn*

"Elliptically Polarized Radiation from Inclined Slots on Cylinders"—*G. Sinclair*

"A Broadband Transition from Coax to Helix"—*C. O. Lund*

"Theory of End-Fire Helical Antennas"—*A. E. Marston and M. D. Adcock*

"Equivalent Circuits for Coupling of Waveguides by Apertures"—*N. Marcuvitz*

**Symposium: NETWORK THEORY**

"Modern Developments in the Topology of Networks"—*R. M. Foster*

"A Summary on the Status of Linear Network Theory"—*J. G. Linvill*

"A General Review of Linear Varying Parameters and Nonlinear Circuit Analysis"—*W. R. Bennett*

**Instruments and Measurements I**  
**Microwave**

"Measuring the Efficiency of a Superhetrodyne Converter by the Input Impedance Circle Diagram"—*H. A. Wheeler and D. Dettinger*

"Electrolytic-Tank Measurements for Microwave Delay Lens Media"—*S. B. Cohn*

"Impedance Instrumentation for Microwave Transmission Lines"—*P. A. Portmann*

"A Michelson Type Interferometer for Microwave Measurements"—*B. A. Lengyel*

"A Broadband High-Power Microwave Attenuator"—*H. J. Carlin*

"An Absolute Method for Measuring Microwave Power of Low Intensity"—*H. Herman*

**Audio**

"The Reproduction of Sound"—*H. F. Olson*

"New Developments in Studio Design in Europe"—*L. L. Beranek*

"The Technique of Television Sound"—*R. H. Tanner*

"The Measurement of Nonlinear Distortion"—*A. Peterson*

**Tuesday Morning, March 8, 1949**

**Antennas II**

"Antenna Systems for Multichannel Mobile Telephone"—*W. Babcock and A. W. Nylund*

"Wide-Angle Metal-Plate Optics"—*J. Ruze*

"The Measurement of Current and Charge Distributions on Transmitting and Receiving Antennas"—*T. Morita*

"The Diffraction Pattern from an Elliptical Aperture"—*R. Adams and K. S. Kelleher*

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#### Passive Networks I - Synthesis

"Amplifier Synthesis through Conformal Transformation"—*J. Pettit and D. L. Trautman, Jr.*

"Exact Design of Bandpass Networks Using  $n$  Coupled Finite-Q Resonant Circuits ( $n=3$  and  $4$ )"—*M. Dishal*

"Network Approximation in the Time Domain"—*W. H. Huggins*

"A Method of Synthesizing the Resistor-Capacitor Lattice Structure"—*J. L. Bower, J. T. Fleck, and P. F. Ordnung*

"The Design of Frequency-Compensating Matching Sections"—*V. Rumsey*

#### Instruments and Measurements II Oscillography

"An Impulse Generator—Electronic Switch for Visual Testing of Wide Band Networks"—*T. R. Finch*

"A 50-Mc Wide-Band Oscilloscope"—*A. Levine and H. Hoberman*

"A Timing-Marker Generator of High Precision"—*R. C. Palmer*

"The Evaluation of Specifications for Cathode-Ray Oscillographs"—*P. S. Christaldi*

"Photographic Techniques in Cathode-Ray Oscillography"—*C. Berkley and H. Mansberg*

#### Electronic Computers

"The Binac"—*J. P. Eckert, Jr., J. W. Mauchly, and J. R. Weiner*

"An Electronic Differential Analyzer"—*A. B. Macnee*

"An Analog Computer for the Solution of Linear Simultaneous Equations"—*R. M. Walker*

"The Electronic Isograph for a Rapid Analog Solution of Algebraic Equations"—*B. O. Marshall, Jr.*

"A Parametric Electronic Computer"—*C. J. Hirsch*

**Tuesday Afternoon, March 8, 1949**

#### Symposium: ELECTRONIC COMPUTERS

"The Binac"—*J. W. Mauchly*

"Mark III Computer"—*H. H. Aiken*

"IBM Type 604 Electronic Calculator"—*Ralph Palmer*

"Electrostatic Memory for a Binary Computer"—*F. C. Williams*

"Counting Computers"—*G. R. Stibitz*

"Programming of a Chess Game on a Computer"—*Claude Shannon*

#### Wave Propagation I - Television

"VHF Television—Propagation Aspects"—*E. W. Allen, Jr.*

"Propagation Variations at VHF and UHF"—*K. Bullington*

"Propagation Tests at UHF"—*J. Fisher*

"A Test of 450-Mc Urban-Area Transmission to a Mobile Receiver"—*A. Aikens and L. Y. Lacy*

"Echoes in Transmission at 450 Mc from Land to Car Radio Units"—*W. R. Young and L. Y. Lacy*

#### Passive Networks II - Analysis

"Impedance Curves for Two-Terminal Networks"—*E. Michaels*

"An Analysis of Triple-Tuned Coupled Circuits"—*N. Mather*

"The Bridged Parallel-Tee Network for Suppressed-Carrier Servo Systems"—*C. F. White*

"Transient Response of Linear Networks with Amplitude Distortion"—*M. Di Toro*

"Spectrum Analysis of Transient-Response Curves"—*H. Samulon*

#### Components and Materials

"Subminiaturization of IF Amplifiers"—*G. Shapiro and R. L. Henry*

"New Applications of a Four-Terminal  
[Continued on page 47]

# New Sensational

## NOISE SUPPRESSING PREAMPLIFIER\*

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Designed to achieve a high degree of noise reduction without discernible quality impairment.

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March 7-10.

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1701 Palisade Avenue,

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a man with  
a sore nose*

**Congratulations, sir!** Your bandaged beak is a badge of honor!

It's a symbol of service . . . a sure sign that you, like most of us these days, have been keeping your nose to the grindstone—working your hardest just to keep your family living the way you want them to live.

But what of the future? Your nose can't take it forever. Someday you'll want to retire, to follow the hobbies and take the trips and do the things that you've always dreamed of doing.

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But the best way, the sure and steady way, is to buy 'em automatically!

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## **AUTOMATIC SAVING IS SURE SAVING—U.S. SAVINGS BONDS**



*Contributed by this magazine in co-operation with the Magazine Publishers of America as a public service.*

Capacitor"—A. A. Pascucci  
 "Frequency Control Units"—A. E. Miller  
 "Type 5811 and Type 5807 Tubes, The Smallest Commercial Pentode Amplifiers"—L. G. Hector and H. R. Jacobus  
 "Conductive Plastic Materials"—M. A. Color, A. Lightbody, F. Barnett, and H. Perry

#### Nucleonic Instrumentation

"Industrial Thickness Gauges Employing Radioisotopes"—J. Carlin  
 "The Design of a G-M Counter Tube for High Counting Rates"—W. Managan  
 "Electrometer Tubes and Circuits"—F. H. Starke  
 "Proportional Counter Equipment for Beta Detection"—W. Bernstein  
 "A High-Voltage Supplier for Radiation-Measuring Equipment"—R. Weissman and Stewart Fox

Tuesday Evening, March 8, 1949

#### Symposium: NUCLEAR SCIENCE

"The Fundamental Particles"—D. J. Hughes  
 "The Detection and Measurement of Nuclear Radiation"—H. L. Andrews  
 "The Effects of Ionizing Radiation on Tissue"—J. P. Cooney  
 "The Application of Nuclear Radiation to Industry"—J. R. Menke

Wednesday Morning, March 9, 1949

#### Television I

"A Unidirectional Reversible-Beam Antenna for Twelve-Channel Reception of Television Signals"—O. M. Woodward, Jr.  
 "A Method of Multiple Operation of Transmitter Tubes Particularly Adapted for Television Transmission in the Ultra-High-Frequency Band"—G. H. Brown, W. C. Morrison, W. L. Behrend, and J. G. Reddeck  
 "Transient-Response Tests in the WPTZ Television Transmitter"—R. C. Moore  
 "The Synchronization of Television Stations"—R. D. Kell  
 "Television by Pulse-Code Modulation"—W. M. Goodall

#### Symposium:

##### RADIO AIDS TO NAVIGATION

"Radio Technical Commission for Aeronautics - Its Program and Influence"—J. H. Dellinger  
 "Frequency Allocations to the Aeronautical Services about 400 Mc"—V. I. Weihe  
 "Experimental Multiplexing of Functions in the 960 to 1660-Mc Frequency Spectrum - Its Influence on Weight and Complexity of Equipment"—P. C. Sandretto and R. I. Colin  
 "The Philosophy and Equivalence Aspects of Long Range Radio Navigation Systems"—M. K. Goldstein  
 "The Future in Approach and Landing Systems"—H. Davis

#### Active Circuits I

"G Curves as an Aid in Circuit Design"—K. A. Pullen  
 "A Direct-Coupled Amplifier Employing a Cross-Coupled Input Circuit"—J. N. Van Scoyoc and G. Warnke  
 "Annular Circuits for High-Power Multiple-Tube Generators at VHF"—D. H. Preist  
 "Considerations on Electronic Multicouplers"—W. R. Aylward and E. G. Fubini  
 "Improved Degenerative Regulators"—Y. P. Yu

#### Instruments and Measurements III

"Radar Circuit Powered X-Ray Movie Equipment for Operation at 150 Frames per Second"—D. C. Dickson, Jr., C. T. Zavales, and L. F. Ehrke

[Continued on page 48]

# See and Hear THESE 3 NEW PRODUCTS ... AT TERMINAL

## MAGNETIC TYPE "TWIN-TRAX" TAPE RECORDER



**Model 810-B** Records one full hour on standard half-hour recording tape! Wide range (50-9,000 cps  $\pm$  3 db)!

"Twin-Trax" cuts tape costs in half by use of twin recording and erase heads for forward and reverse tape travel. Automatic reverse is fast and smooth, does not interrupt continuity. Will also play back single track recordings made on any tape recorder. Ten tube, 5 watt amplifier has separate microphone and tuner-phonograph inputs. Individual bass and treble controls. Flutter and "wow" guaranteed less than 0.1%. No capstan tape slippage, nor can rubber rimmed drive develop "flats".

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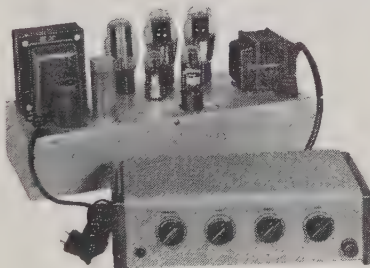
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### "TWIN-TRAX"

**Model 808** Basic "Twin-Trax" mechanism as used in above

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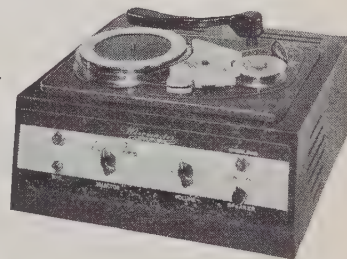
Within the range of its 10 watt power rating, Model 12A3 is equal in all respects to the famous Brook 30-watt amplifiers.

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Complete with separate pre-amplifier and control cabinet

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**Model H** No other wire recorder offers so much for so little! Professional-type wire moving mechanism has automatic shut-off. Records and plays up to one hour spools. May be played through self-contained speaker; or through any radio via specially designed extra fidelity phono oscillator; or direct connection. 7-tube amplifier specially designed for wide-range wire recording. Built-in phonograph with lightweight arm plays up to 12" records for listening and "dubbing" on wire. Minimum controls for easy operation include selector switch, volume control, speaker monitoring switch and volume level indicator.

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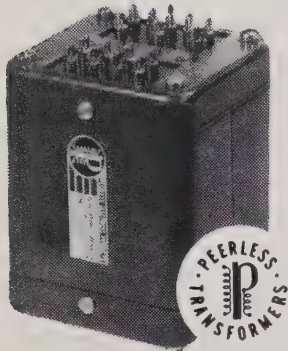
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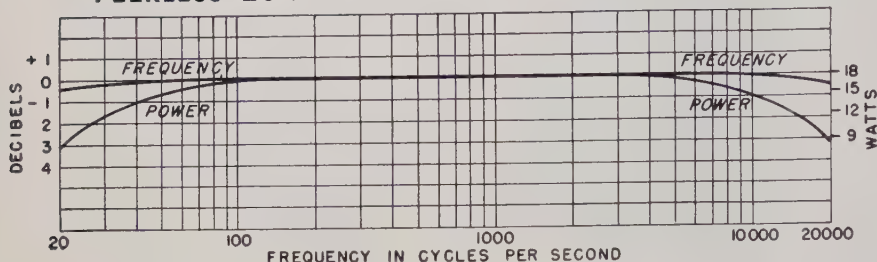
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- "A Magnetostrictive Delay Line"—E. Braddurd
- "An Electromechanical Strain-Gauge Multiplier"—C. Woods, E. St. George, L. Isenberg, and A. C. Hall
- Electronics I - Tube Design and Engineering
- "Microphonism Investigation"—Lester Feinstein
- "A Critical Survey of Methods of Making Ceramic-to-Metal Seals and Their Use for Vacuum Tube Construction"—R. P. Wellinger
- "Rugged Tubes"—G. W. Baker
- "An Improved Method of Testing for Residual Gas in Electron Tubes and Vacuum Systems"—E. W. Herold
- "Design Factors, Processes, and Materials for the Envelope of a Metal Kinescope"—R. D. Faulkner and J. C. Turnbull

**Wednesday Afternoon  
March 9, 1949**

### Television II

- "The Measurement of the Modulation Depth of Television Signals"—R. P. Burr
- "Development and Performance of Television Camera Tubes"—R. B. Janes, R. E. Johnson, and R. S. Moore
- "An Anastigmatic Television Deflection Yoke and Associated Circuits"—K. Schlesinger
- "A High-Efficiency Sweep Circuit"—B. M. Oliver
- "Progress Report on UHF Television"—T. T. Goldsmith
- Wave Propagation II
- "An Analysis of Distortion Resulting from Two-Path Propagation"—I. H. Gerks
- "On the Origin of Solar Radio Noise"—A. V. Haeff
- "Geometrical Representation of the Polarization of a Plane Electromagnetic Wave"—G. A. Deschamps
- "Propagation Conditions and Transmission Reliability in the Transitional Microwave Range"—T. F. Rogers
- "A Forward-Transmission Echo-Ranging System"—D. B. Harris
- Active Circuits II
- "A Laboratory and Analytical Analysis Comparing the L-C Toroidal Filter with the Parallel-Tee Feedback Amplifier Filter"—A. J. Stecca
- "A Peak-Picker Circuit"—M. J. Parker
- "Low-Frequency Synchronized Sawtooth Generator Providing Constant Amplitude Sweep with Aperiodic Synchronization Input"—P. Yaffee
- "High-Power Sawtooth Current Synthesis from Square Waves"—H. E. Kallman
- "Regenerative Amplifiers"—Y. P. Yu
- "A Rectifier Filter Chart"—R. Lee
- Instruments and Measurements IV
- "High-Impedance Millivolt Measurements above 5 Mc"—W. K. Volkers
- "Some Aspects of the Performance of Mixer Crystals"—P. D. Strum
- "A Wide-Band Audio Phasemeter"—J. R. Ragazzini and L. A. Zadeh
- "A Device for Admittance Measurements in the 50- to 500-Mc Range"—W. R. Thurston
- "An Improved RF Capacitometer"—E. F. Travis and T. M. Wilson
- "A Radio Frequency Discharge Phenomenon and its Application to Mechanical Measurements"—K. S. Lion and J. W. Sheetz
- Electronics II - Electron-Tube Cathodes
- "The Effects of Various Barium Compounds with Respect to Cold-Cathode"

[Continued on page 49]

Behaviour as a Function of Life in a Glow Discharge"—H. Jacobs and A. P. LaRocque

"Oxide-Cathode Properties and their Effects on Diode Operation at Small Signals"—G. C. Dalman

"Microanalysis of Gas in Cathode-Coating Assemblies"—H. Jacobs and B. Wolk

"Exposure of Secondary-Electron-Emitting Surfaces to the Evaporation from Oxide Cathodes"—C. W. Mueller

"The Use of Thoriated-Tungsten Filaments in High-Power Transmitting Tubes"—R. B. Ayer

Thursday Morning, March 10, 1949

#### Systems II - Relay Systems

"A Microwave System for Television Relaying"—J. Z. Miller and W. B. Sulinger

"Synchrodyne Phase Modulation of Klystrons"—V. Learned

"Intercity Television Radio Relays"—W. H. Forster

"Video Design Considerations in a Television Link"—M. Silver, H. French, and L. Staschover

"A Six-Channel Urban Mobile System with 60-Kc Spacing"—R. C. Shaw, P. V. Dimock, W. Strack, and W. C. Hunter

#### Navigation Aids I

"The Determination of Ground Speed of Aircraft Using Pulse Radar"—I. Wolff, S. W. Seeley, Earl Anderson, and W. D. Hershberger

"The Dimeal Aircraft Approach and Landing System"—L. B. Hallman, Jr.

"Theoretical Aspects of Nonsynchronous Multiplex Systems"—W. D. White

"Band-Pass Circuit Design for Very-Narrow-Band, Very-Long-Range Direction Finder Receivers to Minimize Bearing Error Due to Receiver Mistuning"—M. Dishal and H. Morrow

"Crystal Control at 100 Mc for Aerial Navigation"—S. H. Dodington

#### Symposium: MARKETING

"Market Research"—E. H. Vogel

"The Application of Market and Field Research in Product Planning and Design"—O. H. L. Jensen

"Sales Planning and Distribution"—Lee McCanne

"National Advertising"—M. F. Mahony

"Sales Training and Sales Promotion"—W. E. Macke

#### Electronics III - Electron-Tube Theory

"General Solution of the Two-Beam Electron-Wave-Tube Equation"—A. V. Haeff, H. D. Arnett, and W. Stein

"Aspects of Double-Stream Amplifiers"—J. R. Pierce, W. B. Hebenstreit, and A. V. Hollenberg

"On the Theory of Axial Symmetric Electron Beams in an Axial Magnetic Field"—A. L. Samuel

"Electron Beams in Axial Symmetric Magnetic and Electric Fields"—C. C. Wang

"Space-Charge Effects and Frequency Characteristics of CW Magnetrons Relative to the Problem of Frequency Modulation"—H. W. Welch, Jr.

Thursday Afternoon, March 10, 1949

#### Symposium: GERMANIUM AND SILICON SEMICONDUCTORS

"Electrical Properties of Germanium and Silicon"—K. Lark-Horovitz

"The Metallurgy of Germanium and Silicon Semiconductors"—J. H. Scaff

"Theory of Rectification"—F. Seitz

"Transistors"—W. H. Brattain

#### Information Transmission and Noise

"Design in Nature as Exploited by the Communication Engineer"—L. A. de Rosa

"Experimental Determination of Correlation"

(Continued on page 50)

## NEW TRIONIC ARM

## CARTRIDGE HOLDER

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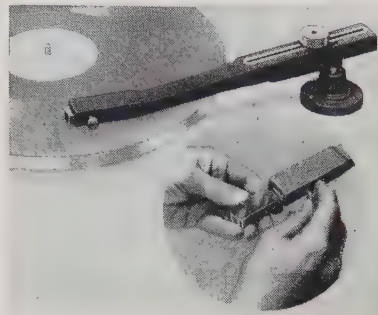
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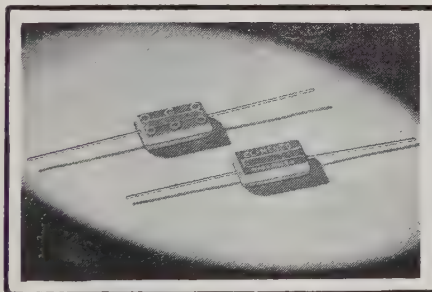
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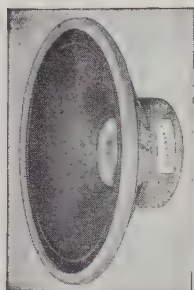
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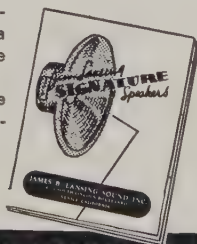
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tion Functions and the Application of these Functions in the Statistical Theory of Communications"—T. P. Cheatham, Jr.

"The Transmission of Modulation Through Band-Limited Transmission Systems"—W. P. Boothroyd and E. M. Creamer, Jr.  
"Signal-to-Noise Improvement Through Integration in a Storage Tube"—J. V. Harrington and T. F. Rogers  
"The Theory of Receiver Noise Figure"—L. J. Cutrona

#### Navigation Aids II

"Very-High-Frequency Airborne Navigational Receiver and Antenna System"—A. C. Kandoian, R. T. Adams, and R. C. Davis

"Certain New Performance Criteria for Localizer and Glide-Slope Ground Installations"—P. R. Adams

"Phase and Other Characteristics of 330-Mc Glide-Path Systems"—S. Pickles

"Principles of Volume Scan"—D. Levine

"The Control of Structural Resonance Effects on the Radio Bearings of an Aircraft High-Frequency Direction Finder"—M. Goldstein

#### Oscillators

"An Analysis of Oscillator Performance under Varying Load Conditions and an Electronic System for Automatic Load Compensation"—E. Mittelmann

"Low-Power Wide-Tuning-Range UHF Oscillators"—J. N. Pettit and F. J. Kamp-hoefner

"Reactance-Tube Modulation of Phase-Shift Oscillators"—F. R. Dennis and E. P. Felch

"A Low-Distortion AF Oscillator"—C. W. Clapp and C. L. Hackley

"An Automatic-Frequency-Control System for Mechanically Tuned Oscillators"—J. G. Stephenson

Electronics IV - New Forms of Tubes  
"The Graphophon - A Picture Storage Tube"—L. Pensak

"The Pencil-Type UHF Triode"—G. M. Rose and D. W. Power

"Practical Applications of the Resnatron in the High-Power Transmitter Field"—W. W. Salisbury

"The Electron Coupler - A New Tube for the Modulation and Control of Power at the Ultra-High Frequencies"—C. L. Cuccia and J. S. Donal, Jr.

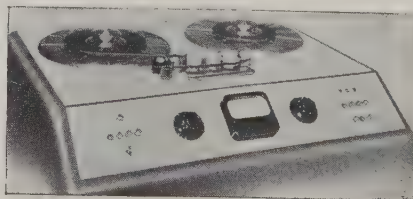
"A Low Power Wide-Band CW Magnetron"—L. R. Bloom and W. W. Cannon

## NEW PRODUCTS

[from page 32]

### NEW TAPE RECORDER

• Fairchild Recording Equipment Corporation, 88-06 Van Wyck Blvd., Jamaica 1, N.Y., has announced the Fairchild tape



recorder, with deliveries scheduled early in 1949.

The instrument easily out-performs requirements set by the latest NAB specifications, the company said. At 15 inches per second tape speed, the Fairchild machine delivers the high fidelity performance formerly thought possible only at 30 inches

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Box 100, Audio Engineering.

### WANTED

W. E. Carrier Telephone and Carrier Telegraph Equipment and components. Filters, repeating coils, transformers, equalizers. Type CF1, CF2, H, C, and other carrier equipment, telephone and telegraph repeaters. Box 101, Audio Engineering.

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per second, thereby doubling the recording time for any specific amount of tape, and reducing the operating speed of the equipment. This results in lower costs of operation, and nicer controls of starting, stopping, spotting editing, etc.

Quality of reproduction is termed superb. In numerous tests, the finest ears have been unable to detect the difference in an instantaneous A-B test in switching between the monitoring of a live studio program and the same program from the Fairchild tape recorder. This type test is made possible by applying the program to the tape with the recording head a couple of inches ahead of the playback head and listening to the recorder material from the tape almost at the instant it is applied. This monitoring is available at all times in regular operation. Tests show better than 60 db signal-to-noise ratio with a maximum total harmonic distortion of two per cent.

An especially-designed synchronous motor drive provides an over-all time accuracy of better than one-half second in 30 minutes' playing time.

Features of the instrument also include plug-in type construction, both mechanical and electrical, for uninterrupted service; interlock system to prevent accidental erasing; volume indicator for reading recording level, etc.; adjustment of playback head during operation; and, automatic control in event of tape break.

A unit developed by Dr. D. G. C. Hare is the basis for the new Fairchild tape recorder, and Dr. Hare, who has made an intensive study of magnetic recording over a long period, part of which was in connection with special military applications, has been retained by the Fairchild corporation as a consultant in these matters.

Detailed information about the Fairchild tape recorder is available from the manufacturer.

#### "HOW TO MAKE GOOD RECORDINGS"

• Audio Devices, Inc., 444 Madison Ave., New York 22, N. Y., has recently published the ninth edition of a complete handbook for the recordist, entitled "How to Make Good Recordings." This revised and expanded edition contains 144 pages of helpful, up-to-the-minute information on all phases of sound recording equipment, materials, and technique. It is an authoritative guide which covers the entire subject in easily read, non-technical language—profusely illustrated with photographs, charts, and drawings.

Subjects covered in this new revised edition include the following: How a Recorder Works—How to Choose a Recorder—The Requirements of a Recording Disc—Selecting the Proper Cutting and Playback Needles—Adjusting the Turntable Drive—Setting the Cutting Angle—Adjusting the Depth of Cut—Determining the Correct Recording—Volume—Controlling the Thread—Making a Radio Recording—Mike Technique—Instrumental Recording—Acoustically Treating the Studio—Putting Together a Recording "Show"—Use of Sound Effects—Common Recording Difficulties and Their Remedies—and many others. The book also includes a 14-page glossary of terms commonly used in the sound recording field.

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**Play BOTH 33 $\frac{1}{3}$  and 78 RPM Records WITHOUT changing Needle Pressure or similar adjustments**

**N**OT HAVING to change needle pressure or make similar adjustments—in switching from 33-1/3 to 78 RPM Records with Astatic FL Series Pickups—has done much to put these revolutionary phonograph playing arms in a leading position in the new long-playing equipment field. All that the user need do is change cartridges. Takes only a second, because they are designed to fix themselves in playing position on the same slip-in principle which firmly joins barrel and cap of many modern fountain pens. New engineering, mechanically and electrically, assures perfect tracking, unparalleled reproduction, at the featherlight needle pressure of five grams. Comparable reproduction quality at lower cost is available in other Astatic units, which round out the complete Astatic Long-Playing Line. Write for new brochure, giving full details, illustrations.



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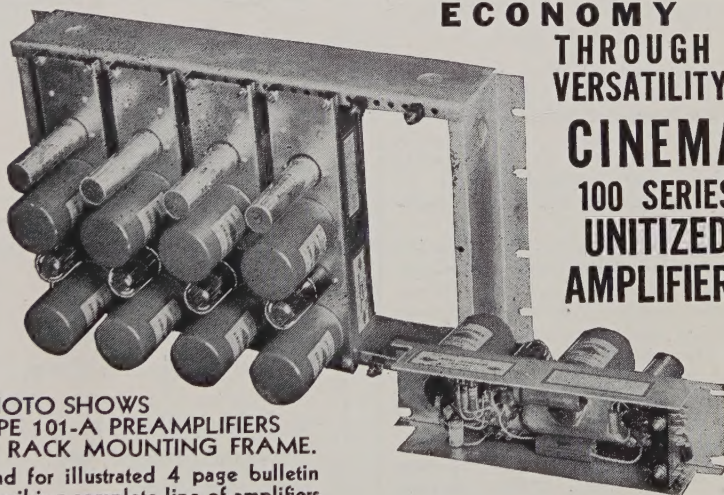


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describing complete line of amplifiers.

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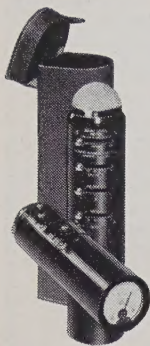
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- ★ Size: 11½ inches long — 2½ inches in diameter.
- ★ Weight: 2 lbs., 7 oz.

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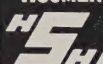
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## ADVERTISING INDEX

Altec Lansing Corp.....	38
Arcturus Engineering Corp.....	2
Arnold Engineering Co.....	8
Astatic Corporation, The.....	51
Audio Development Co.....	43
Audio Devices, Inc.....	Cover 2
Audio Instrument Co.....	44
Camera Equipment Co.....	36, 40
Chicago Transformer Corp.....	35
Cinema Engineering Co.....	51
Clarkstan Corp.....	49
Daven Company, The.....	Cover 3
Diamond Tool Engineering Co.	52
Electro Motive Mfg. Co., Inc.	49
Electro-Voice, Inc.....	31
Fairchild	
Recording Equip. Corp.....	39
Hartley, H. A. Co., Ltd.....	52
Hollywood Sound Institute.....	50
Institute of Radio Engineers.....	52
Lansing, James B. Sound, Inc.	50
LeBel, C. J.....	32
Lenkurt Electric Co.....	38
Maurer, J. A. Inc.....	7
Peerless Elec. Prods.....	48
Pickering & Co., Inc.....	41, 50
Presto Recording Corp.....	5
Professional Directory.....	32
Racon Electric Co., Inc.....	4
Radio Corp. of America	
Broadcast Equip. Div.)	
17, 18, 19, 20	
Reeves Soundcraft Corp.....	33
Scott, H. H. Inc.....	52
Simpson Electric Company.....	37
Somerset Laboratories, Inc.....	45
S.O.S. Cinema Supply Corp.	50
Sylvania Electric Products Inc.	1
Terminal Radio Corp.....	47
Trans-World	
Radio-Television Corp.....	50
United Transformer Corp.	
Cover 4	
U. S. Recording Co.....	32
Vibration Systems, Inc.....	50
Wells, Winston.....	32
Westfield	
Metal Products Co., Inc.....	48

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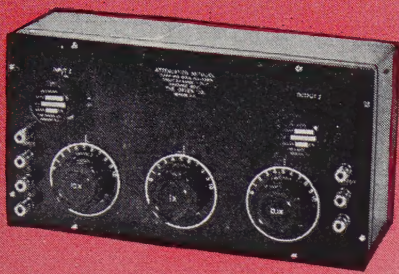
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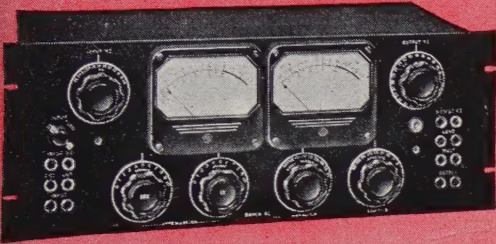
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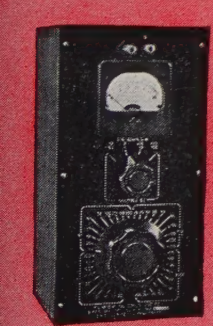
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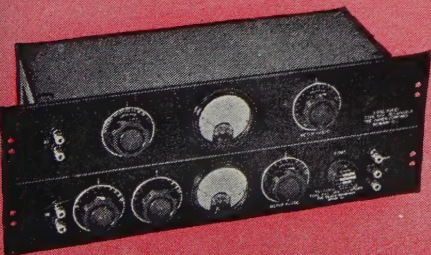
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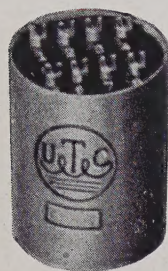
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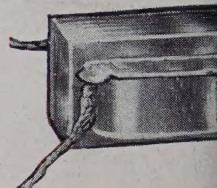
Weight 1 ounce ...  $\frac{7}{8}$  Dia. ...  
1-3/16 overall height ...  
40 to 15000 cycles ... 13 types\*

Type	Application	Pri. Imp.	Sec. Imp.	List Price
0-1	Mike pickup or line to 1 grid	50, 200, 500	50,000	\$13.25
0-4	Single plate to 1 grid	8,000 to 15,000	60,000	10.50
0-6	Single plate to 2 grids	8,000 to 15,000	95,000	12.00
0-8	Single plate to line	8,000 to 15,000	50, 200, 500	13.25
0-12	Mixing and matching	50, 200	50, 200, 500	12.00
0-13	Reactor, 200 Hys-no D.C., 50 Hys-2MA D.C.			9.50

### U. T. C.

### SUB-OUNCER SERIES

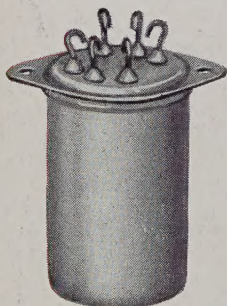
Weight  $\frac{1}{2}$  ounce ...  
 $9/16 \times \frac{5}{8} \times \frac{7}{8}$  ... Nylon bobbin  
structure ... 200 to 5000 cycles.



Type	Application	Level	Pri. Imp.	D.C. in Pri.	Sec. Imp.	List Price
50-1	Input	+ 4 V.U.	200		250,000	
			50	0	62,500	\$5.60
50-2	Interstage/3:1	+ 4 V.U.	10,000	0	90,000	5.60
50-3	Plate to Line	+ 23 V.U.	10,000		200	
			25,000	3/1.5 mil.	500	5.60
50-4	Output	+ 20 V.U.	30,000	1.0 mil.	50	5.60
50-5	Reactor 50 Hy at 1 mil. D.C. 3000 ohms D.C. Res.					5.10

\*For complete list, write for Catalog PS-409

## TO SPECIFICATION

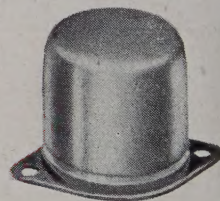


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Weight  $1\frac{1}{2}$  ounce ...  $15/16 \times 1\frac{3}{8} \times 1\frac{3}{8}$  high ... all standard  
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reactors ... dual units (input &  
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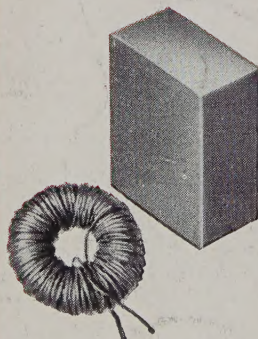
### HERMETICALLY SEALED SUB-OUNCERS

Weight .8 ounce ...  $15/16 \times 1\frac{3}{8} \times 13/16$  high ... all standard  
sub-ouncer designs ... plus spe-  
cial units up to 200 KC.



### SUB-OUNCER PERMALLOY DUST TOROIDS

Weight  $\frac{1}{2}$  ounce uncased .8 ounce  
hermetically sealed. These mini-  
atured HQE coils have characteristics  
similar to our standard HQA, C,  
and D coils with little reduction in  
Q considering minute size.



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